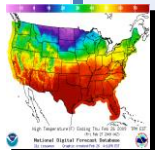# An Analysis of Runoff Risk Advisory Guidance for 2011

First Year Assessment of Daily Forecast Guidance for Runoff Risk in Wisconsin

**Dustin Goering**

North Central River Forecast Center

Overview

1. **Introduce Analysis Details & Goal**

2. **Review Simulated Runoff Event Definition**

3. **Review Runoff Event Categories & Thresholds**

4. **Introduce Concept of Runoff Type**

5. **Introduce concept of a "Warning Day"**

6. **Review Assorted Histograms and Spatial Maps**

7. **Identify Inconsistent Basin Behavior & Opportunities for Improvement**

8. **Next Steps**

National Weather Service

Protecting Lives and Property
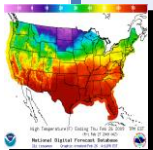
What Is Being Analyzed?

- **Combine 1 daily forecast run for every day in 2011 (365 runs)**
  - *Morning run (t_0 = 12Z) used*
  - *Sum daily values into an <u>Analysis Accumulation (</u>AA) for each basin*

- **Each forecast run consists of:**
  - *Duration is 240 hours (10 days) on a 6 hour time step*
  - *5 days of QPF & 10 days of forecast temperatures included*

- **This analysis involves 216 basins in or surrounding Wisconsin**

- **Note this only includes forecast runs:**
  - *A particular calendar day will be simulated multiple times in this analysis*
  - *A forecast weather event could be included in several daily runs*
  - *Analysis Accumulations are <u>not synonymous </u>to calendar year annual totals*

What Is the Goal of This Analysis?

➢ **Evaluate many components of this project for spatial & quantitative consistency over the test year:**

  ➢ *Base model parameters used in this product*

  ➢ *Accumulation of basin simulated runoff events*

  ➢ *Effect of basin thresholds on creating medium and high risk runoff events*

➢ **Answer basic questions by product users:**

  ➢ *How often will my area be flagged for high risk of runoff?*

➢ **Identify areas for product improvement:**

  ➢ *Any RFC basin calibration issues?*

  ➢ *Opportunities to adjust basin thresholds to allow more or less high risk events to occur to create a spatially more consistent product?*

Overview

National Weather Service

Protecting Lives and Property
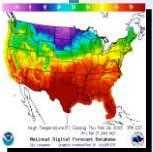
What Is a Simulated Runoff Event?

➢ **Simulated runoff event definition:**

    ➢ *Starts when three conditions are met:*

        1. **SAC-SMA Interflow runoff > 0**
        2. **Rain+melt time series > 0**
        3. **SAC-SMA UZTWD = 0**

    ➢ *Event ends when one of these criteria is not met*

    ➢ *Event start time is assigned to the beginning of the time step when all criteria is present*

    ➢ *Event end time is the first time step one criteria is not met + 6 hours*

        ➢ **Conservative factor compensating for water to move through fields to waterways**

    ➢ *The interflow runoff for the event is summed and used to determine the runoff risk*

        ➢ **Runoff is in depth (mm) over the basin**

Overview

1. **Introduce Analysis Details & Goal**

2. **Review Simulated Runoff Event Definition**

3. **Review Runoff Event Categories & Thresholds**

4. **Introduce Concept of Runoff Type**

5. **Introduce concept of a "Warning Day"**

6. **Review Assorted Histograms and Spatial Maps**

7. **Identify Inconsistent Basin Behavior & Opportunities for Improvement**

8. **Next Steps**

National Weather Service

Protecting Lives and Property
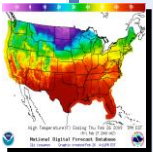
What are Runoff Categories?

➢ **To help differentiate runoff risk, basin thresholds were developed**

  ➢ *Historical comparisons of real field scale & small watershed runoff events to the model were completed to arrive at a universal basin threshold method*

  ➢ *These basin specific thresholds are in terms of event runoff*

➢ **Time for a basin can be broken down to always be in only 1 of 3 categories:**

  ➢ *C1 = Low Risk, no runoff event is simulated*

  ➢ *C2 = Medium Risk, runoff event simulated but < basin threshold*

  ➢ *C3 = High Risk, runoff event simulated and >= basin threshold*
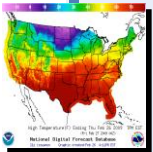
What are Runoff Categories?
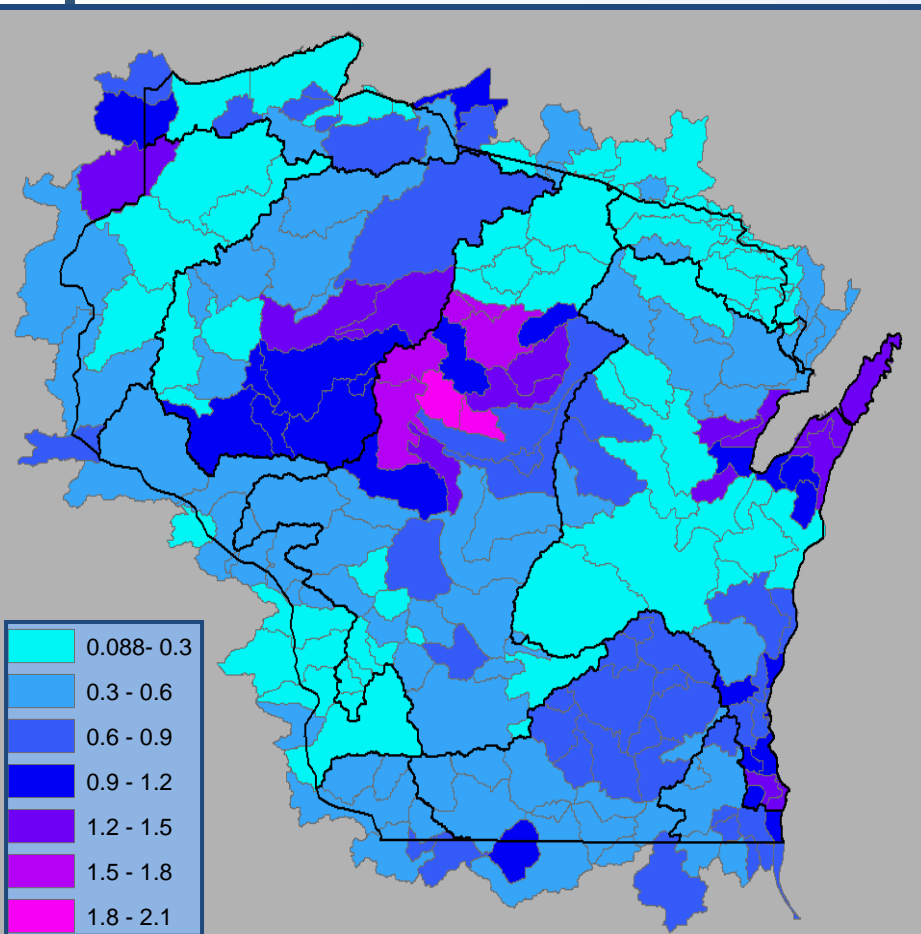
- ➤ **Thresholds are in terms of an event runoff depth specific to each basin**

- ➤ **(Runoff event < threshold) == C2**

- ➤ **(Runoff event >= threshold) == C3**

Legend:
- 0.088- 0.3
- 0.3 - 0.6
- 0.6 - 0.9
- 0.9 - 1.2
- 1.2 - 1.5
- 1.5 - 1.8
- 1.8 - 2.1

Overview

1. **Introduce Analysis Details & Goal**

2. **Review Simulated Runoff Event Definition**

3. **Review Runoff Event Categories & Thresholds**

4. **Introduce Concept of Runoff Type**

5. **Introduce concept of a "Warning Day"**

6. **Review Assorted Histograms and Spatial Maps**

7. **Identify Inconsistent Basin Behavior & Opportunities for Improvement**

8. **Next Steps**

National Weather Service

Protecting Lives and Property

What is the Runoff Type?

➢ **Every simulated runoff event includes a flag noting the source of the runoff**

  ➢ *Runoff type is determined by comparing the rain+melt time series against a time series of forecast precipitation (liquid form only)*

➢ **Runoff Types are:**

  ➢ *F0 :: Runoff event is due to rainfall only*

     ➢ **If (rain+melt is = forecast precip) → *input is all rainfall***

  ➢ *F1 :: Runoff event is due to combination of rainfall & snowmelt*

     ➢ **If (rain+melt > forecast precip & forecast precip) > 0 → *input is a mix***

  ➢ *F2 :: Runoff event is due to snowmelt only*

     ➢ **(If rain+melt is > 0 and the forecast precip is = 0) → *input is all snowmelt***

Overview

1. **Introduce Analysis Details & Goal**
2. **Review Simulated Runoff Event Definition**
3. **Review Runoff Event Categories & Thresholds**
4. **Introduce Concept of Runoff Type**
5. **Introduce concept of a "Warning Day"**
6. **Review Assorted Histograms and Spatial Maps**
7. **Identify Inconsistent Basin Behavior & Opportunities for Improvement**
8. **Next Steps**

National Weather Service

Protecting Lives and Property
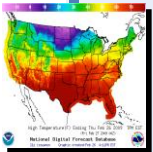
What is a Warning Day?

➢ **DATCP instituted the idea of a 72 hour warning period for runoff risk**

  ➢ *This period is to allow applied manure to break down and be absorbed into the soil thus minimizing its impact if it were to runoff*

  ➢ *The webpage hosted by DATCP imposes this 72 hour restriction in its color coding of basins in Wisconsin*

➢ **To mimic this restriction and calculate statistics comparable to what users see on the webpage, "Warning Days" were defined**

  ➢ *WD1 :: $T_0 - T_{72}$ (Days 1 – 3)*

  ➢ *WD2 :: $T_{24} - T_{96}$ (Days 2 – 4)*

  ➢ *WD3 :: $T_{48} - T_{120}$ (Days 3 – 5)*

 ➢ *WDX :: $T_{120} - T_{240}$ (Days 5 – 10)*

Warning Days

- **A basin is coded medium or high risk if a simulated event occurs at any time in that Warning Day.**
  - *High risk overrules medium risk*
  - *Multiple events could occur in a warning day, however <u>only one event is required</u> to make the entire 3 day period coded for that risk*

- **Example of Warning Day concept**

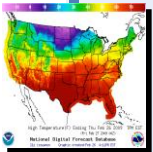| T0	1	2	3	4	5	6	7	8	9	10
WD1										
WD2										
WD3										
WDX										
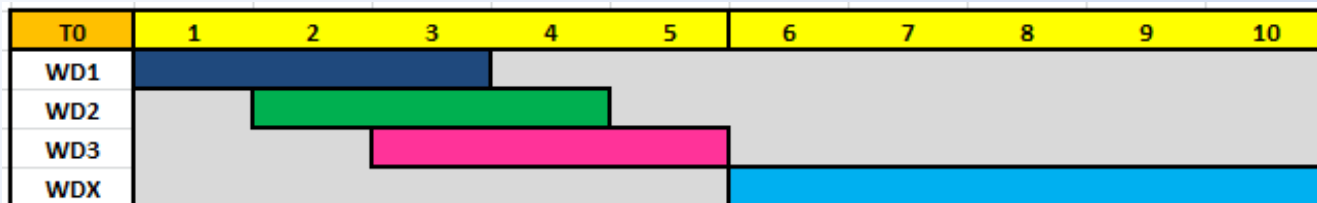
Note Forecasts Overlap in Time

➤ **Remember any given day will be simulated multiple times**

➤ **Therefore, a given weather event will be tallied many times**

➤ **Example of 6 daily runs in succession**
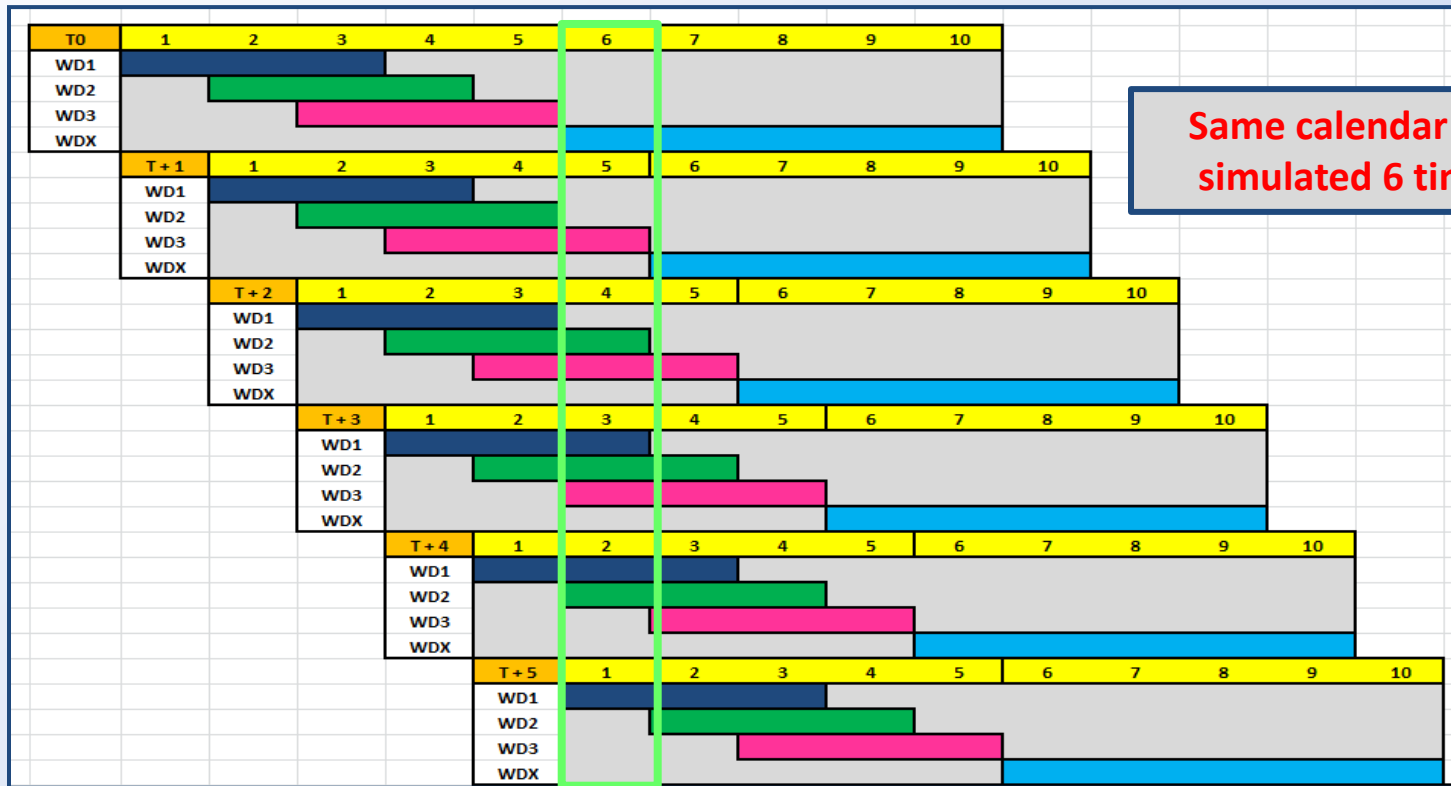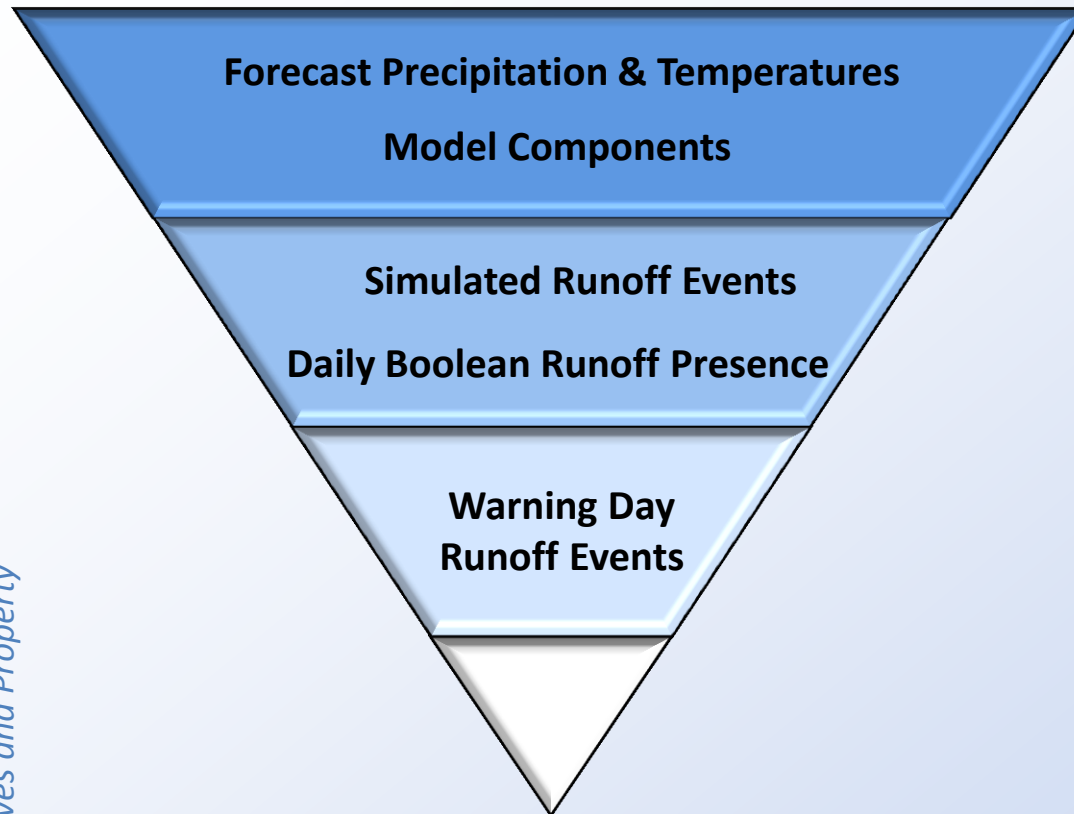

Same calendar day simulated 6 times

Overview

National Weather Service

Protecting Lives and Property

Process of Arriving at Public Guidance

Forecast Precipitation & Temperatures

Model Components

Meteorologic Forcings

RFC Soil and Snow Models

Simulated Runoff Events

Daily Boolean Runoff Presence

Analysis/Research/Programming

Simplifying Output

**Warning Day
Runoff Events**

Consolidating Output for Real World Application
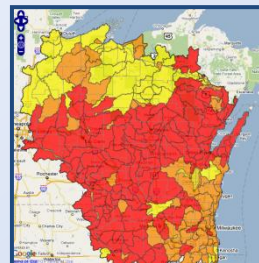
Public Webpage

Displaying Forecast Guidance for Public Use

National Weather Service

Protecting Lives and Property

Data Analysis Overview

1. **The following model parameters were analyzed:**

   ➢ *Forecast Precipitation*   *(FMAP)*

   ➢ *Rain+Melt*   *(RAIM)*

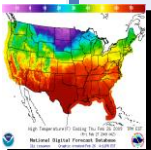   ➢ *SAC-SMA Interflow Runoff*   *(INTRO)*

   ➢ *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**

   ➢ *Review Raw Simulated Events*

      ○ **Number of events , Amount of runoff, and Total Time per Risk Category**

   ➢ *Review in Boolean Perspective*

      ○ **Does period in question have at least one event = 1, otherwise = 0**

   ➢ *Review in Warning Day Perspective*

      ○ **Equivalent to RRAF map hosted by WI DATCP webpage**

   ➢ *Review in Runoff Type Perspective*

      ○ **Look at impacts of runoff type (rainfall, snowmelt, or both)**

National Weather Service

Protecting Lives and Property

Forecast Precipitation

➢ **Every forecast run contained 120 hours of QPF**

➢ **Investigate Analysis Accumulation (AA) by summing basin data from every forecast run together**

➢ **Focus on spatial and quantitative anomalies, not literal amount of precipitation**
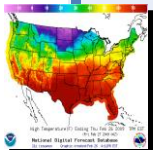
Distribution of Basin Analysis Accumulated Daily QPF
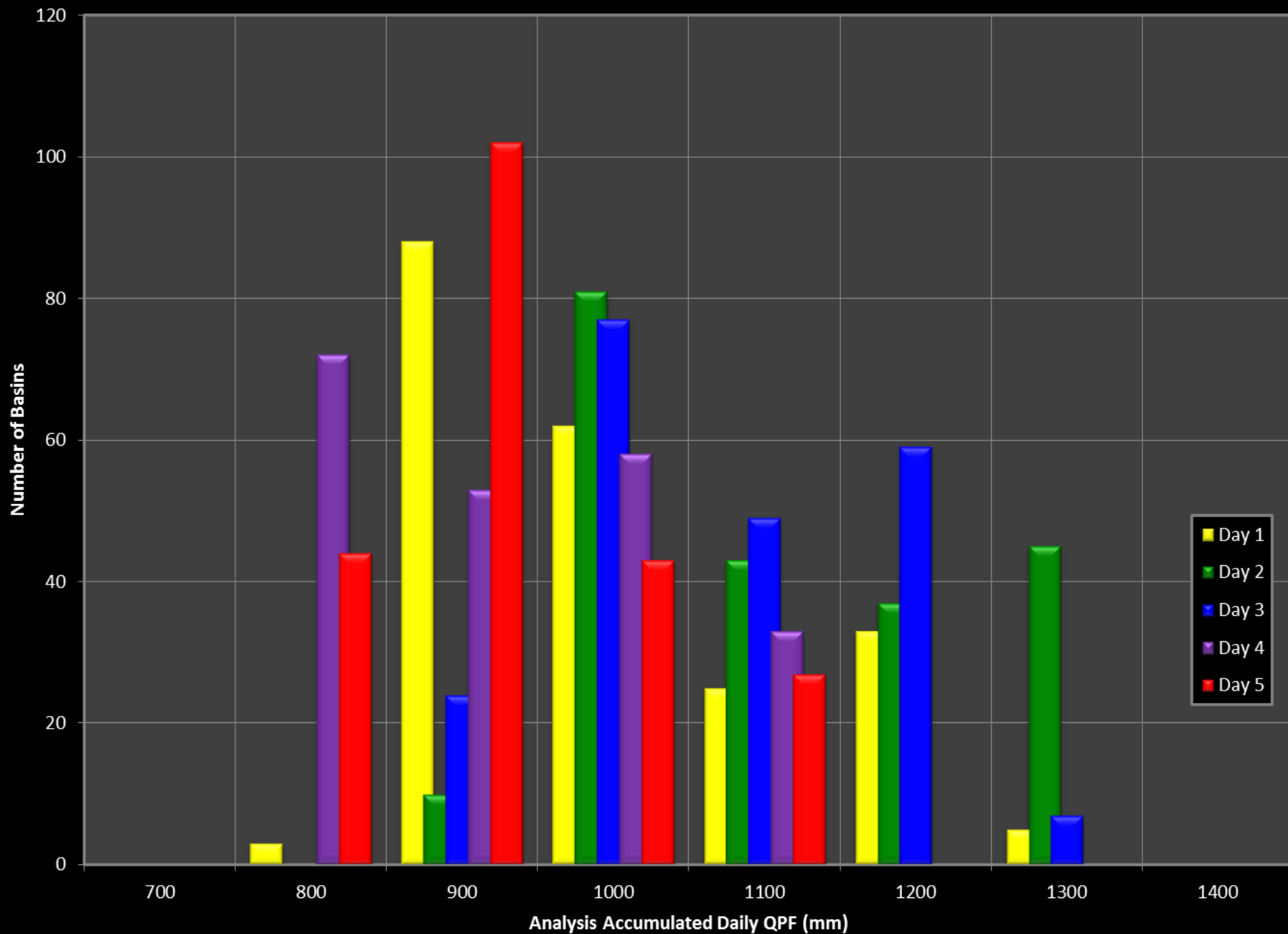
Forecast Precipitation

➢ **Days 2 and 3 have higher accumulations overall**

➢ **Days 4 and 5 have lower accumulations overall**

➢ **All Basin Analysis Accumulation Statistics (in mm)**

	Med	**Max**	**Min**	**Median % Total QPF**
Day 1	927	1220	792	19.7%
Day 2	1032	1288	875	22.1%
Day 3	1006	1208	839	21.6%
Day 4	863	1059	712	18.2%
Day 5	844	1093	744	18.4%
Total	4650	5857	3972	
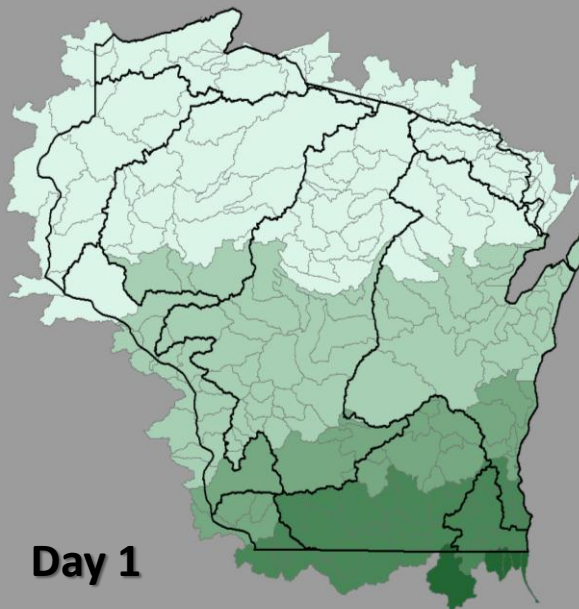
Day 1
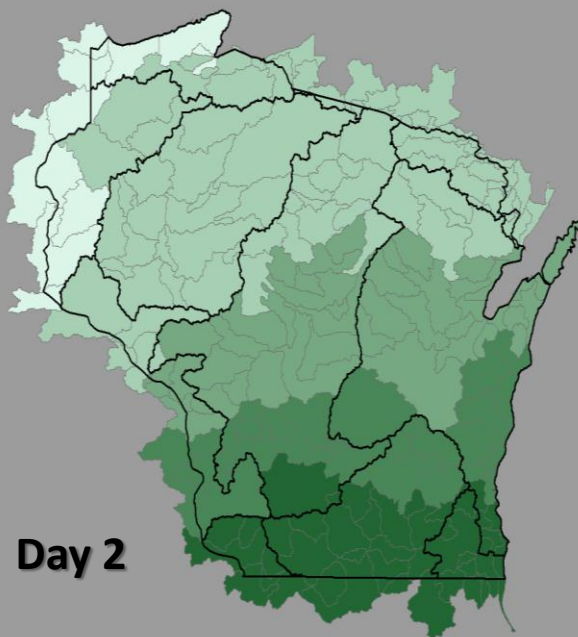
Day 2
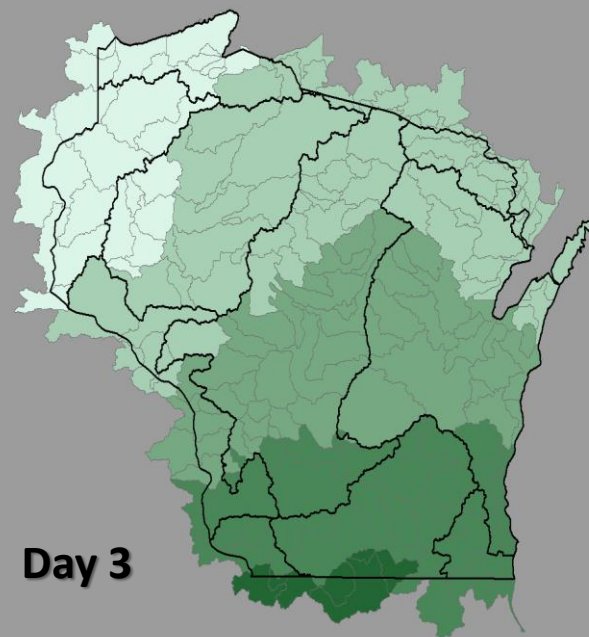
Day 3
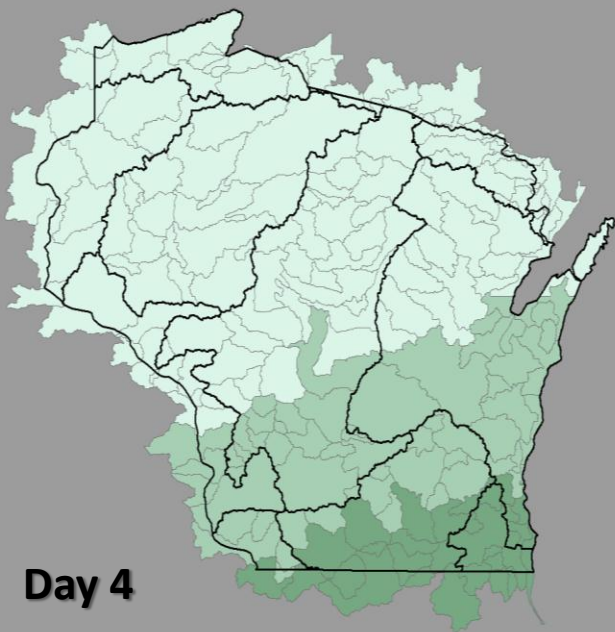
Day 4

Day 5

Analysis Accumulation
of Daily QPF (mm)

744 - 900

900 - 1000

1000 - 1100

1100 - 1200

1200 - 1300
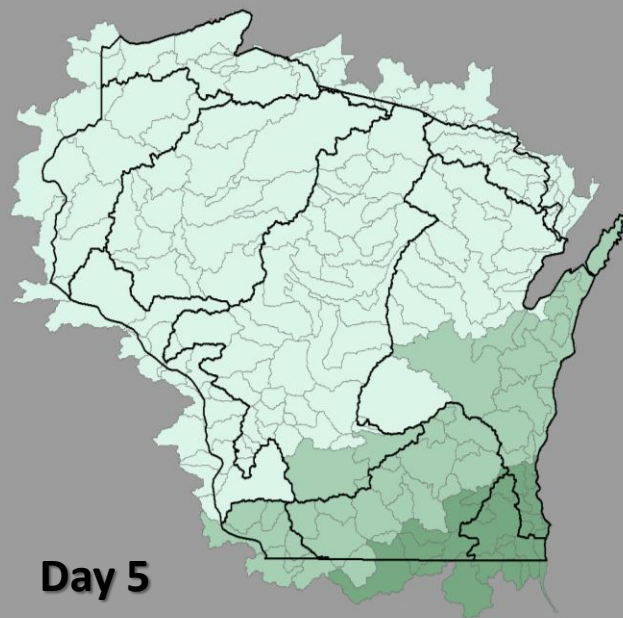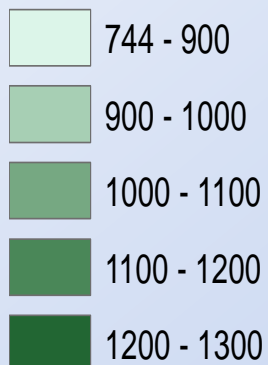
Day 1
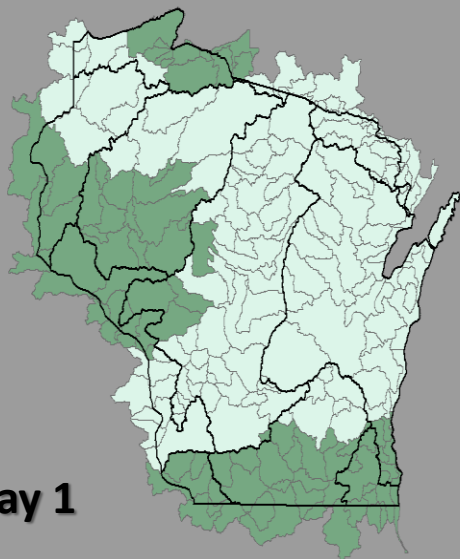
Day 2
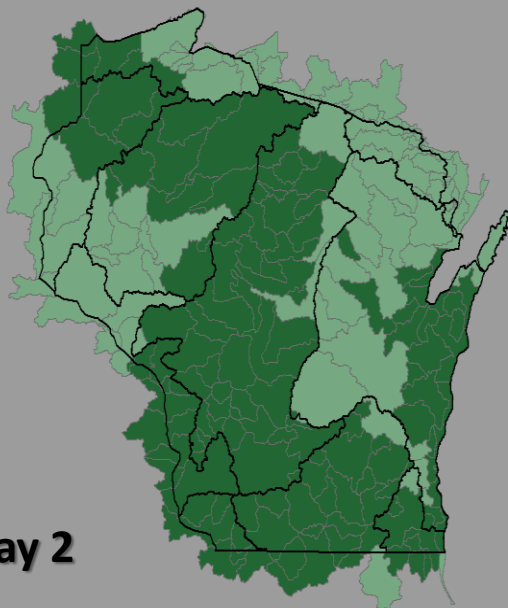
Day 3
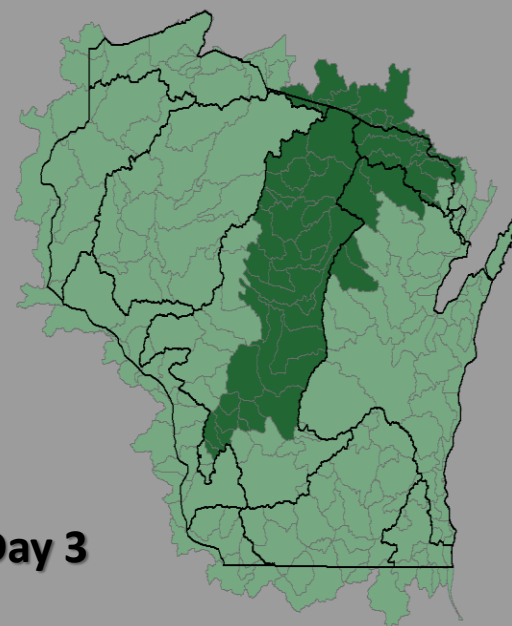
Day 4
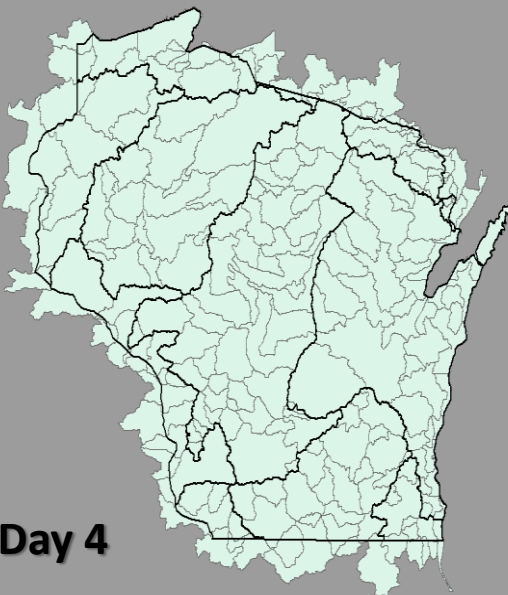
Day 5

Daily Percent of Analysis Accumulation Total QPF

- 16 - 20
- 20 - 22
- 22 - 24
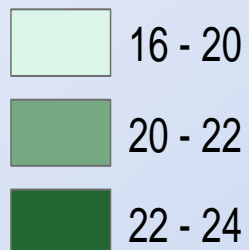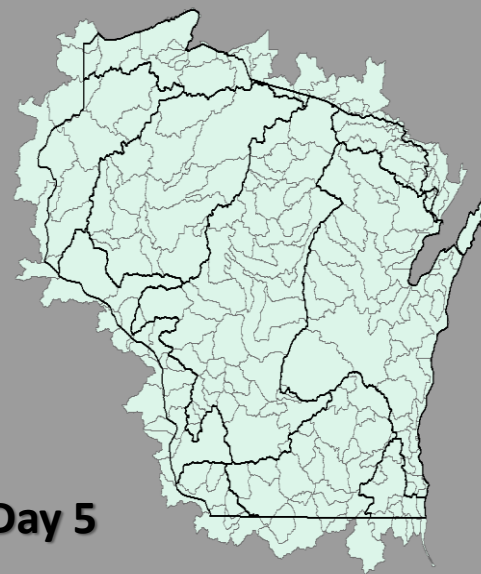
Percentage of Forecast Run Daily QPF with QPF Greater than Zero

All Basins Median % of Runs with QPF > 0
D1 :: 46.6%
D2 :: 48.5%
D3 :: 46.9%
D4 :: 54.4%
D5 :: 55.3%

Legend: Day 1, Day 2, Day 3, Day 4, Day 5

Y-axis: Number of Basins
X-axis: Percent of Daily Runs
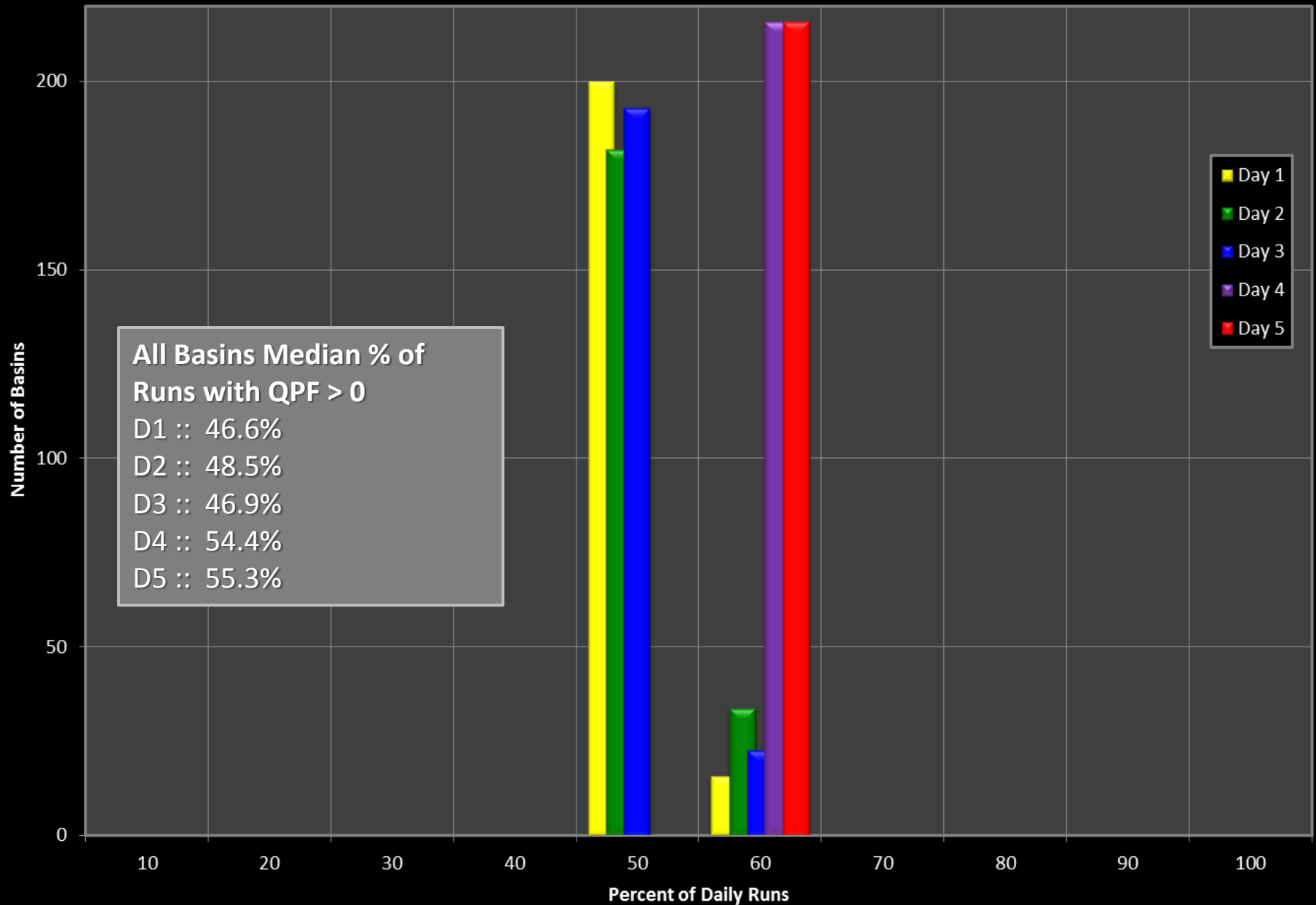
Forecast Precipitation

➢ **Percent of Daily Forecast Runs that QPF > 0 in Any Day**

➢ **Median =   50.1%**

➢ **Max =   57.6%**

➢ **Min =   47.3%**

➢ **Northern Wisconsin basins have most number of days with some QPF in the daily forecast run**

Percent time with QPF > 0

▨	46 - 48
▨	48 - 50
▨	50 - 52
▨	52 - 54
▨	54 - 56
▨	56 - 58

National Weather Service

Protecting Lives and Property
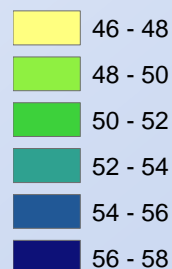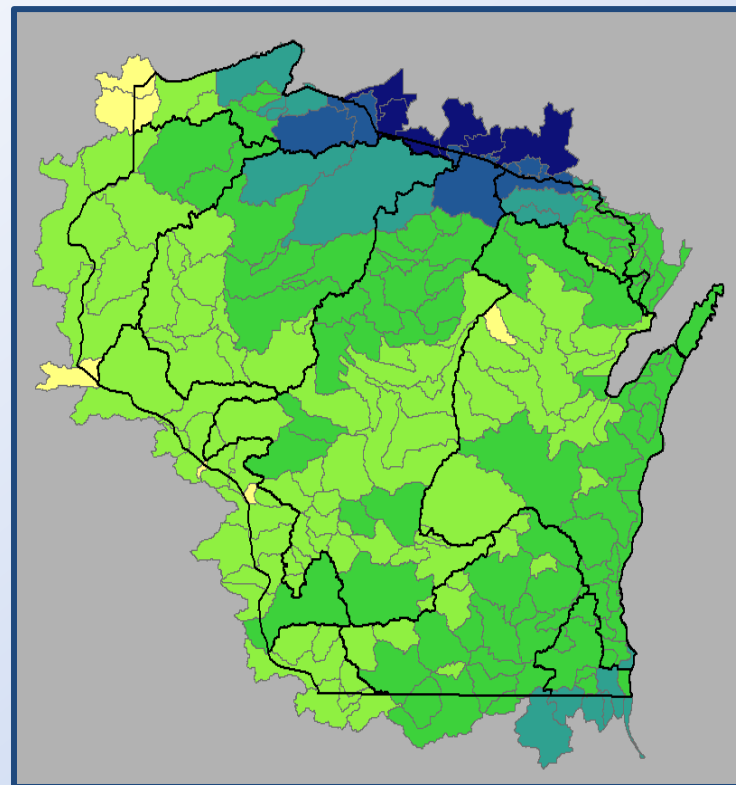
Forecast Precipitation Summary

- ➤ **Analysis Accumulated Total QPF**

- ➤ **Southern basins have highest totals of QPF**

- ➤ **Highest percentage of total QPF on days 2 and 3**

- ➤ **Days 4 & 5 have QPF most often**

- ➤ **Northern basins have most number of days with some QPF**
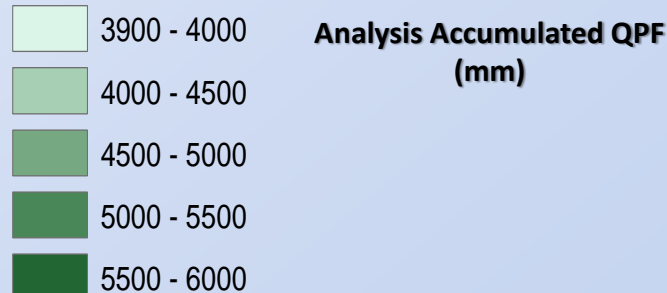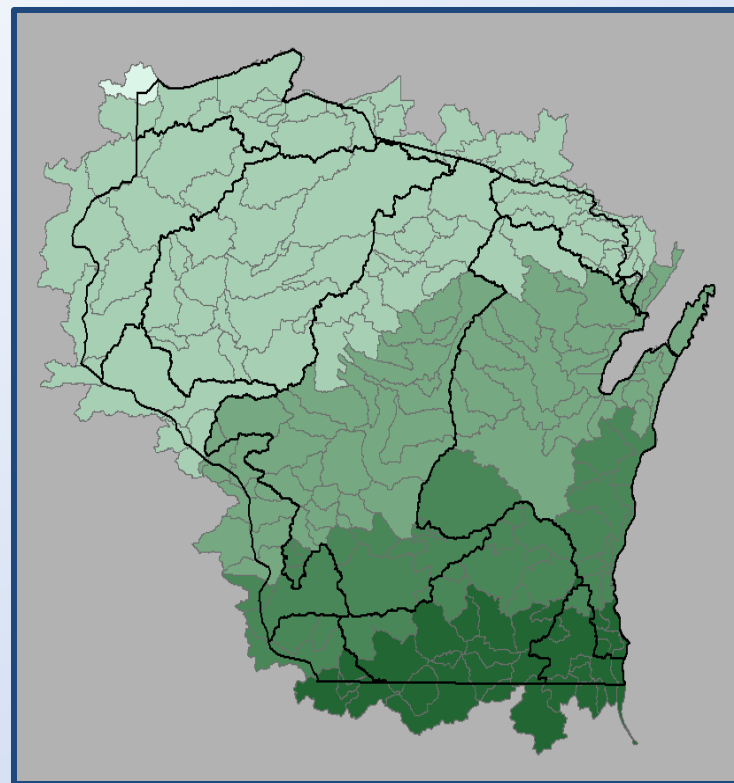
Analysis Accumulated QPF (mm)

	3900 - 4000
	4000 - 4500
	4500 - 5000
	5000 - 5500
	5500 - 6000

Data Analysis Overview

1. **The following model parameters were analyzed:**

   ➢ *Forecast Precipitation*   *(FMAP)*

   ➢ ***Rain+Melt***   ***(RAIM)***

   ➢ *SAC-SMA Interflow Runoff*   *(INTRO)*

   ➢ *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**

   ➢ *Review Raw Simulated Events*
   - **Number of events , Amount of runoff, and Total Time per Risk Category**

   ➢ *Review in Boolean Perspective*
   - **Does period in question have at least one event = 1, otherwise = 0**

   ➢ *Review in Warning Day Perspective*
   - **Equivalent to RRAF map hosted by WI DATCP webpage**

   ➢ *Review in Runoff Type Perspective*
   - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

Rain + Melt (RAIM)

- ➤ **RAIM is an output from the Snow-17 Model ran in every basin**

- ➤ **RAIM is simulated at every time-step in the forecast run**

- ➤ **Look for similar inconsistencies as forecast precipitation**

National Weather Service

Protecting Lives and Property

Distribution of Basin Analysis Accumulated RAIM & Total QPF
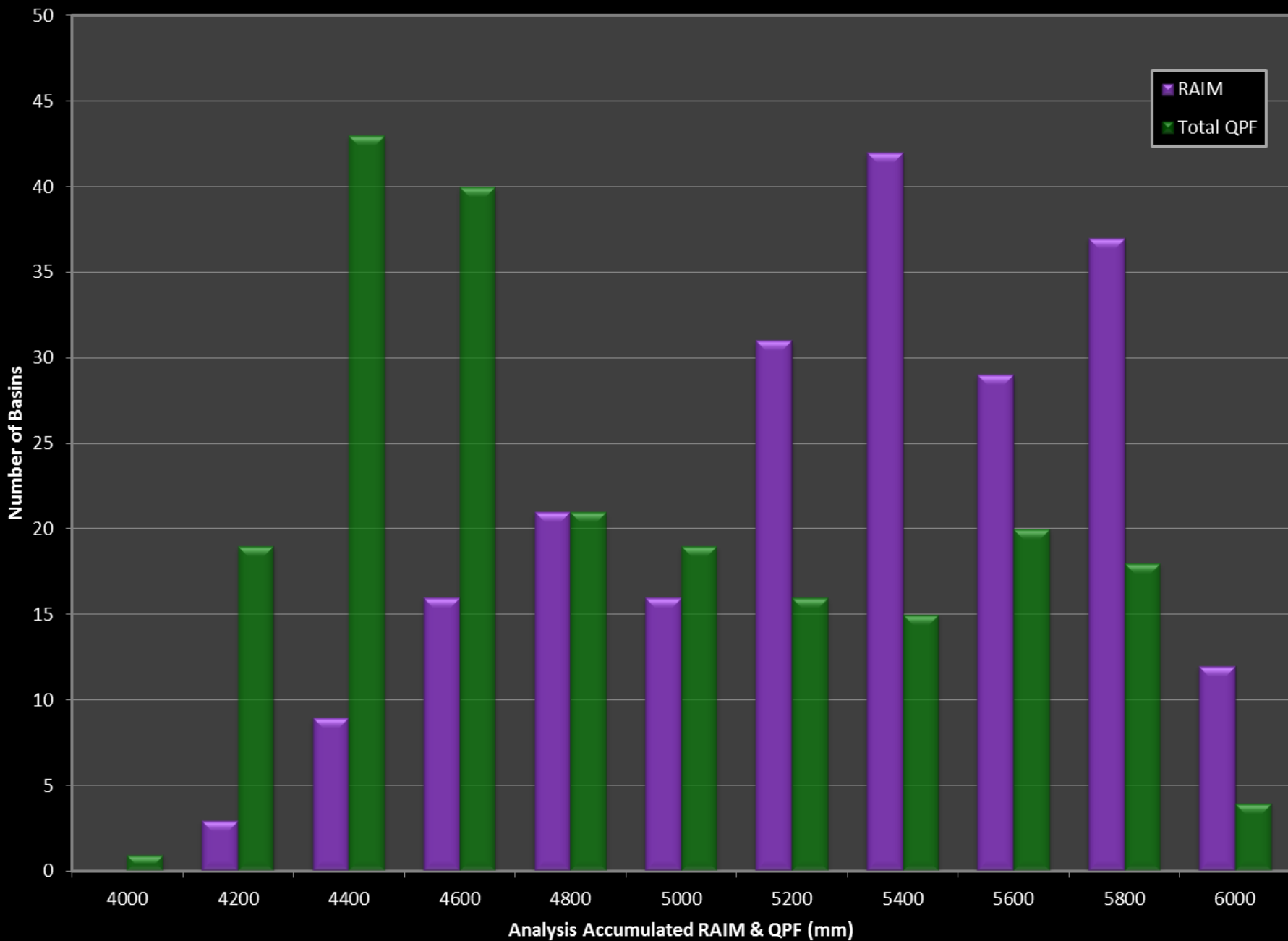
Rain + Melt (RAIM)

➤ **All Basin Analysis Accumulation Statistics (in mm)**

	<u>Med</u>	<u>Max</u>	<u>Min</u>
RAIM	5,266	5,997	4,089
QPF	4,650	5,857	3,972

➤ **Sum of all 216 basins together:**

    ➤ *8% more RAIM than Total QPF*

➤ **Potential Reasons for Differences:**

    ➤ *Starting Conditions not = 0 for snowpack*

       ➤ **Initial snowpack on ground Jan 1st not included in QPF time-series**

       ➤ **Rain on snow events would create RAIM > QPF as that snowpack was melted off**

    ➤ *Forecaster adjustment to snow water equivalents over the year*

       ➤ **Adding or subtracting water from snowpack to align with observations**

Analysis Accumulated RAIM

➢ **Values in mm**

➢ **365 Daily Runs * 40 time steps = 14,600 total time steps**

Legend:
- 4088 - 4200
- 4200 - 4400
- 4400 - 4600
- 4600 - 4800
- 4800 - 5000
- 5000 - 5200
- 5200 - 5400
- 5400 - 5600
- 5600 - 5800
- 5800 - 6000
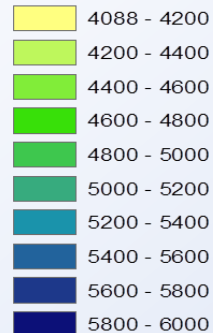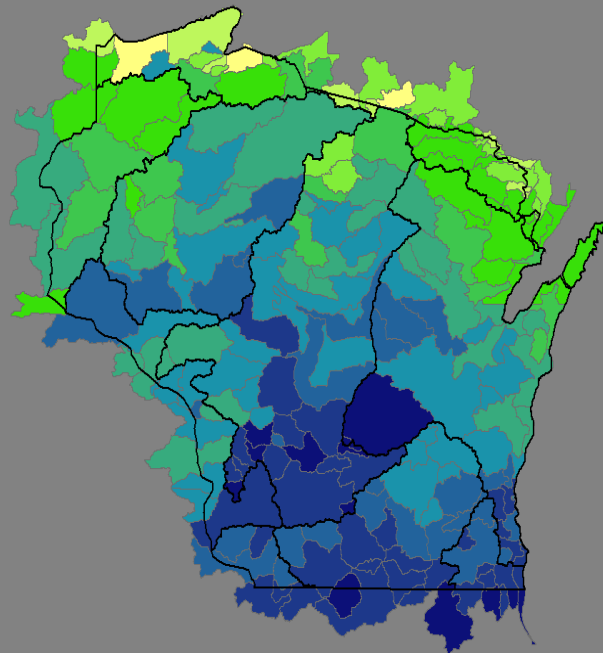
Analysis Accumulated
RAIM - Total QPF (mm)

➢ **25 Basins have negative values (RAIM < QPF)**

➢ **Potential reasons for differences mentioned on previous slide**

Legend:
- (-275) - (-200)
- (-200) - 0
- 0 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000
- 1000 - 1220
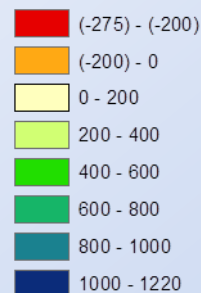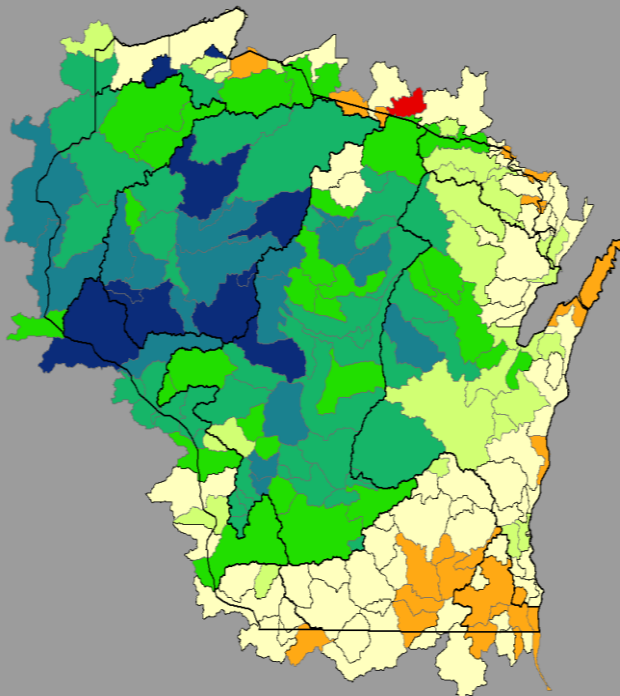
Stratifying Total RAIM

Total RAIM (mm)

Legend (top map):
- 4088 - 4200
- 4200 - 4400
- 4400 - 4600
- 4600 - 4800
- 4800 - 5000
- 5000 - 5200
- 5200 - 5400
- 5400 - 5600
- 5600 - 5800
- 5800 - 6000

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 1.8 Std. Dev.
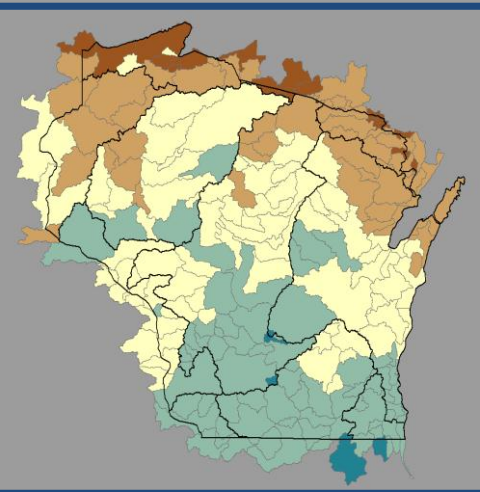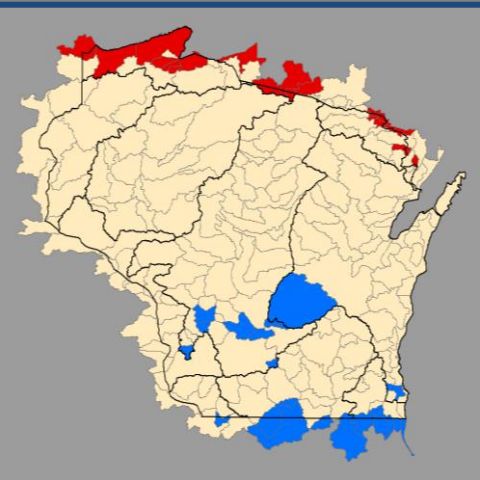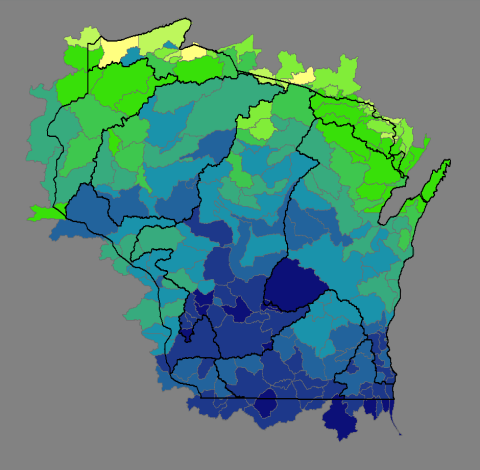
Top 10%		Bottom 10%	
BLEW3	5997	PAUM4	4089
BCDI2	5913	WI13C	4161
PORW3	5880	WI15C	4193
JHNI2	5868	TWFM4	4250
LAFW3	5859	ORCM4	4251
GUNI2	5850	BANM4	4272
IL02C	5844	WI14C	4279
RSPW3	5834	CLKW3	4306
VIOW3	5830	SLSW3	4307
STEW3	5814	MFSM4	4322
BERW3	5808	MRNM4	4349
FEEI2	5801	VLCM4	4372
BROW3	5797	COMW3	4411
RACW3	5796	EWNM4	4423
SIRI2	5796	MI46C	4435
OMCI2	5794	FLOW3	4447
WMTW3	5790	MOQW3	4454
LATI2	5783	WHRW3	4470
BABW3	5754	KFDM4	4492
NIPI2	5744	GRRW3	4516
GLAI2	5741	NIAW3	4523
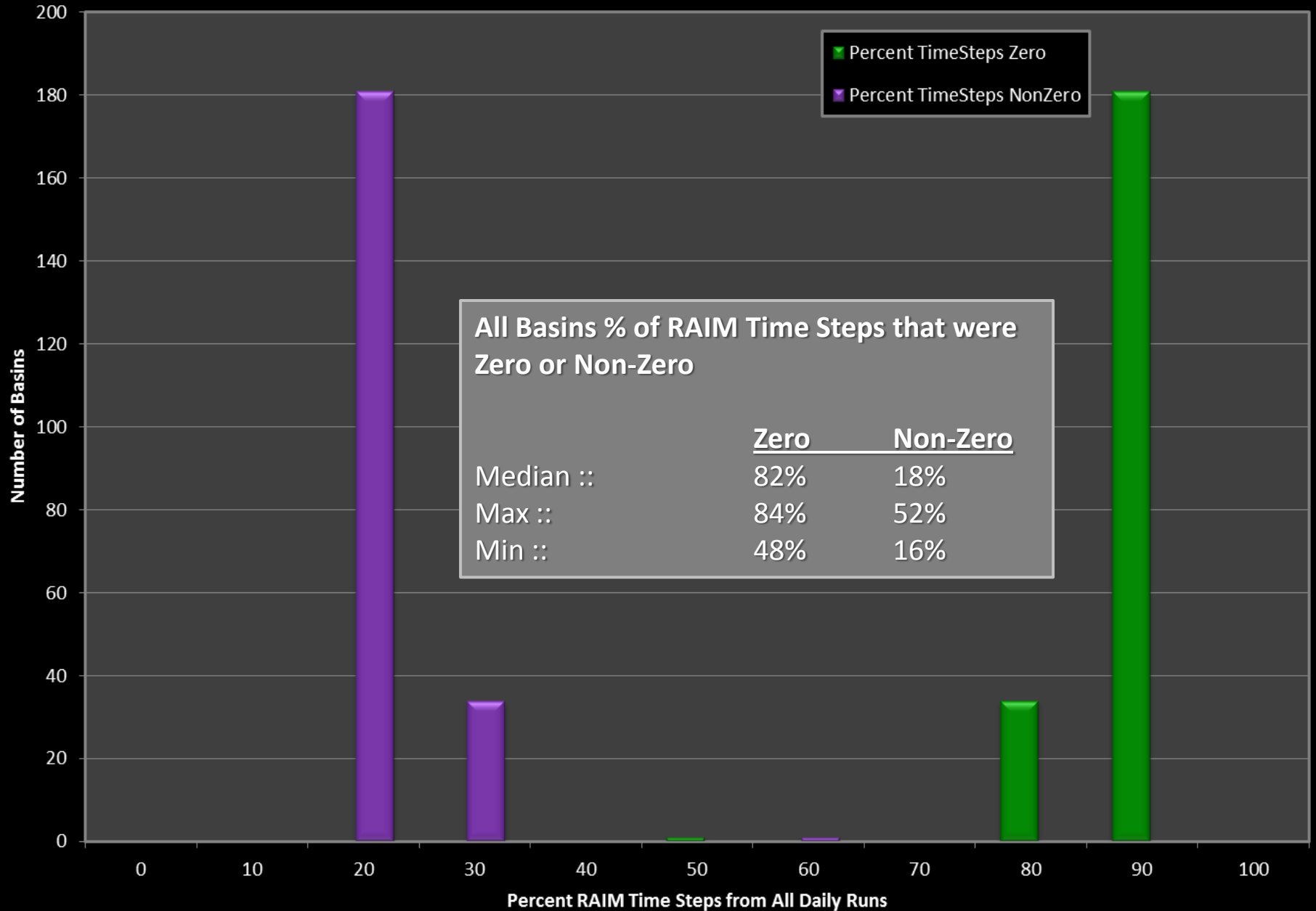
Percent of Time RAIM is Present

Legend (top map):
- 15.9 - 18
- 18 - 20
- 20 - 22
- 22 - 24
- 24 - 60

Percent Time RAIM > 0

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.
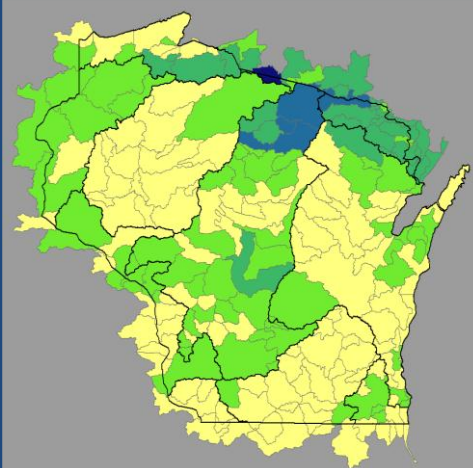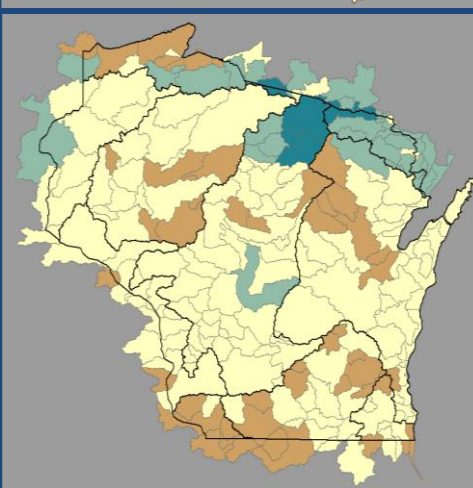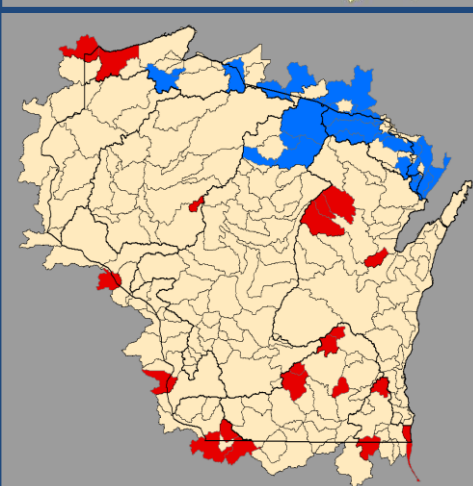
Top 10%		Bottom 10%	
MRNM4	52.1%	APRI2	15.9%
KNGW3	23.7%	JFFW3	16.2%
LTKW3	23.5%	MSCM5	16.2%
RHIW3	23.3%	BLVI4	16.3%
FLRW3	22.7%	WI15C	16.3%
TKDW3	22.1%	BUNW3	16.4%
MCAW3	21.6%	SLSW3	16.5%
MASW3	21.5%	SHAW3	16.5%
CRYM4	21.4%	WPNW3	16.5%
MRSW3	21.4%	MORW3	16.5%
FCEW3	21.3%	EMBW3	16.5%
WHRW3	21.2%	WDRW3	16.5%
COMW3	21.2%	MCGI4	16.6%
SCUW3	21.1%	HOWW3	16.6%
FLOW3	21.1%	WI01C	16.6%
BRKW3	21.0%	THOW3	16.7%
EWNM4	21.0%	MCFW3	16.7%
BGQW3	20.9%	NIPI2	16.7%
PBIW3	20.9%	IL02C	16.7%
KOSM4	20.7%	WKEW3	16.8%
MI33C	20.7%	BEAW3	16.8%

RAIM Summary

- ➢ **Median Basin RAIM > Median Basin QPF**
  - ➢ *All Basin Sums :: 8% more RAIM than Total QPF*

- ➢ **Evaluating Basin (RAIM – QPF) ::**
  - ➢ *In general higher values in central to northern Wisconsin where snow more likely*
  - ➢ *Smallest differences in south where rain more prevalent*

- ➢ **RAIM Spatial Distribution ::**
  - ➢ *In general distribution of higher RAIM aligns with area of higher QPF (Southern Wisconsin)*
  - ➢ *Basins with lowest RAIM values on very northern edge of Wisconsin*
    - • **Least amount of QPF in this region**
    - • **"Auto-pilot" basins that drain directly into Lake Superior → Not reviewed often**

- ➢ **25 Basins had RAIM < QPF**
  - ➢ *More than likely Forecaster adjustments to basin SWE*

- ➢ **In general 18% of the time RAIM was present, 82% it was not**
  - ➢ *Northeastern Wisconsin has highest incidence of RAIM presence*
  - ➢ *Coincides with highest incidence of QPF also in this area*

Data Analysis Overview

1. **The following model parameters were analyzed:**

   - ➤ *Forecast Precipitation* *(FMAP)*
   - ➤ *Rain+Melt* *(RAIM)*
   - ➤ ***SAC-SMA Interflow Runoff*** ***(INTRO)***
   - ➤ *SAC-SMA Upper Zone Tension Water Deficit* *(UZTWD)*

2. **Analysis of Simulated Runoff Events**

   - ➤ *Review Raw Simulated Events*
       - o **Number of events , Amount of runoff, and Total Time per Risk Category**

   - ➤ *Review in Boolean Perspective*
       - o **Does period in question have at least one event = 1, otherwise = 0**

   - ➤ *Review in Warning Day Perspective*
       - o **Equivalent to RRAF map hosted by WI DATCP webpage**

   - ➤ *Review in Runoff Type Perspective*
       - o **Look at impacts of runoff type (rainfall, snowmelt, or both)**

National Weather Service

Protecting Lives and Property
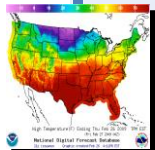
Interflow Runoff (INTRO)

➢ **Opportunity for INTRO to be simulated at every time-step in the forecast run**

➢ **Look for similar inconsistencies as forecast precipitation, RAIM**

➢ **Defining Interflow Runoff :**

  ➢ *Classic definition :: Portion of streamflow resulting from infiltrated water that moves laterally in the subsurface to a channel*

➢ **Sacramento Soil Moisture Accounting Model (SAC-SMA) Interflow Runoff definition is slightly different ::**

  ➢ *In this instance "Interflow runoff" refers to a model component defined in the conceptual SAC-SMA model*

  ➢ *Upper level soil zone must have tension water filled, time step percolation met, and then interflow is based on proportion of free water available in upper zone*

Distribution of Basin Analysis Accumulated Interflow Runoff

All Basins Interflow Statistics (mm)

Median ::   484
Max ::   2176
Min ::   0.63

Interflow Runoff (INTRO)
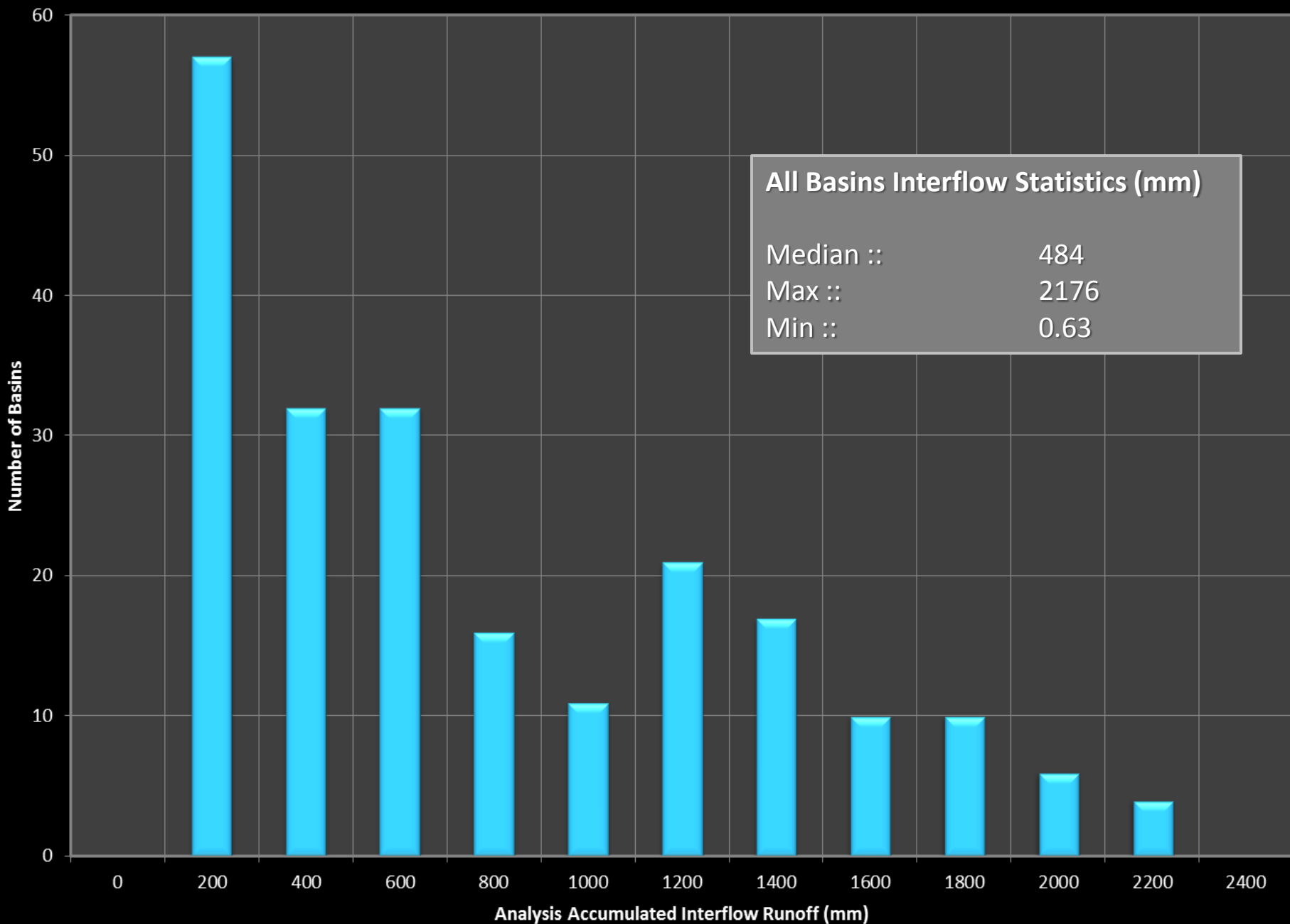
Total Interflow Runoff (mm)
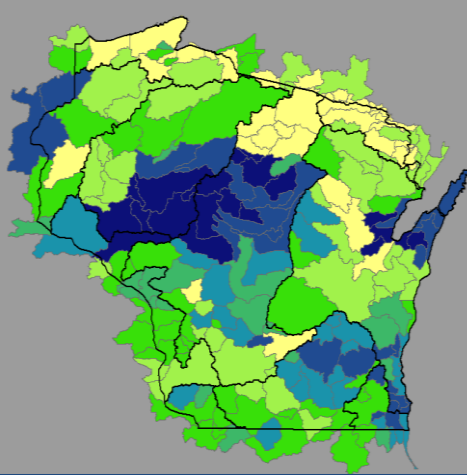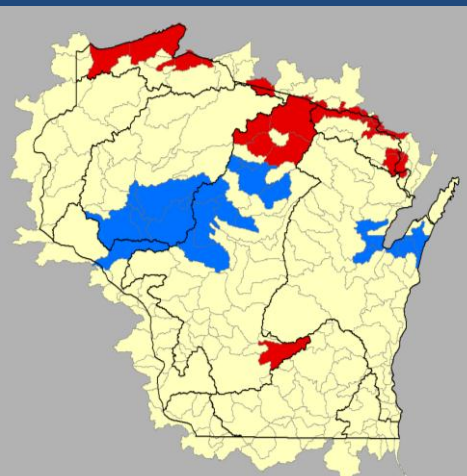
Legend (top map):
- 0.63 - 125
- 125 - 300
- 300 - 600
- 600 - 900
- 900 - 1200
- 1200 - 1600
- 1600 - 2200

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance
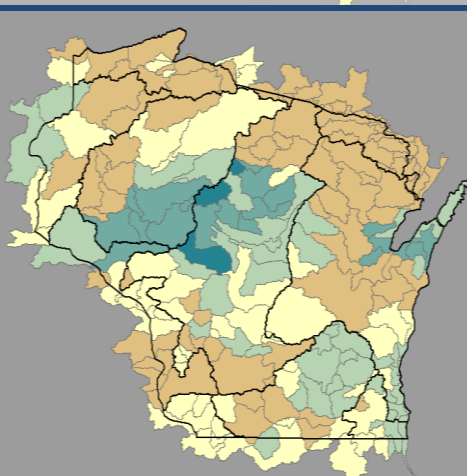
Legend (bottom map):
- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

Top 10%		Bottom 10%	
OWNW3	2176	WI15C	0.6
HATW3	2167	WI13C	0.9
TRIW3	2136	WI14C	1.0
RRLW3	2082	MRNM4	1.8
WISW3	1917	TWFM4	6.8
FLCM4	1866	RRVW3	9.0
HOWW3	1865	VLCW3	10.3
SPDW3	1861	LTKW3	11.2
THOW3	1843	BANM4	12.5
DURW3	1816	FLOW3	12.6
NEIW3	1797	KFDM4	13.2
WI09C	1789	CLKW3	13.2
ECLW3	1775	NIAW3	13.6
ALMW3	1769	COMW3	14.3
WUUW3	1717	WI12C	18.9
KEWW3	1689	BGQW3	19.5
PENW3	1680	KOSM4	19.5
EPLW3	1669	FLRW3	19.7
STRW3	1664	WILW3	22.1
CHFW3	1665	KNGW3	27.6
WI07C	1570	PDSW3	30.6

Percentage of Analysis Accumulated Interflow Runoff Time Steps that were Zero or Non Zero
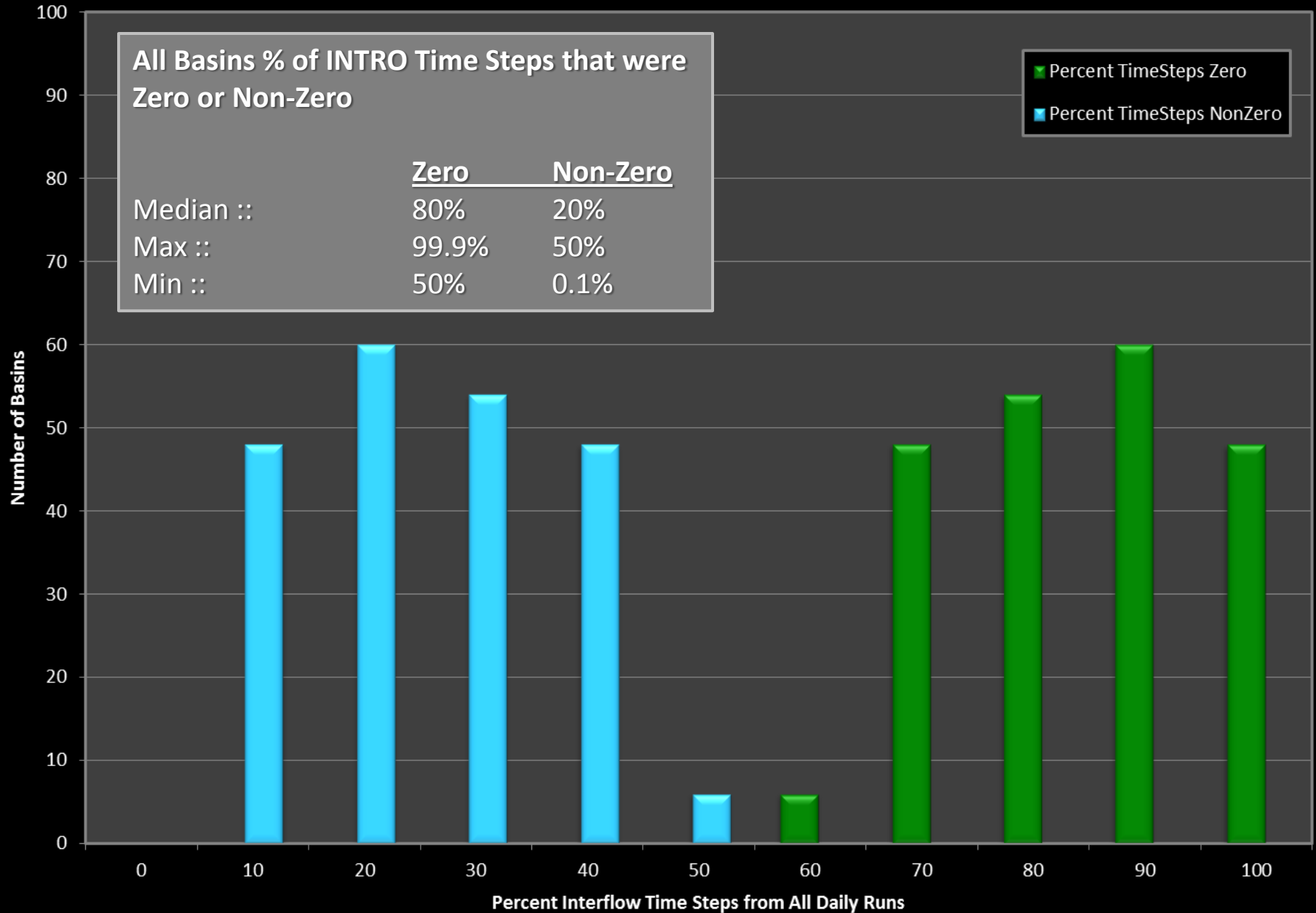
Percent of Time INTRO Present

Legend (top map):
- 0.06 - 5
- 5 - 15
- 15 - 25
- 25 - 35
- 35 - 50

Percent Time INTRO > 0

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
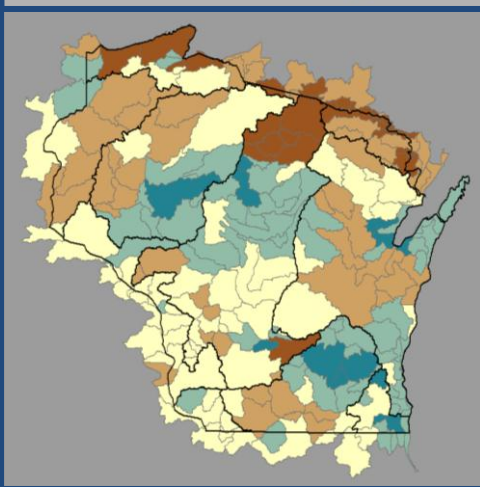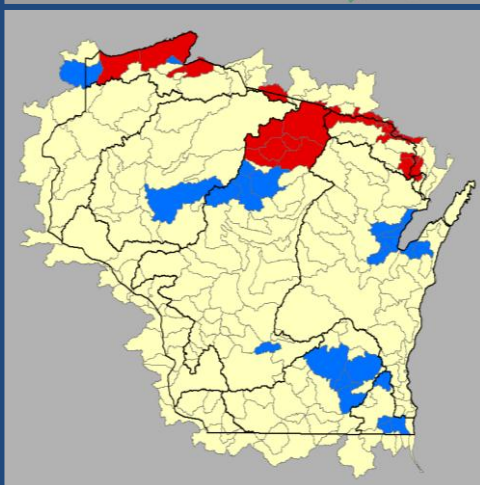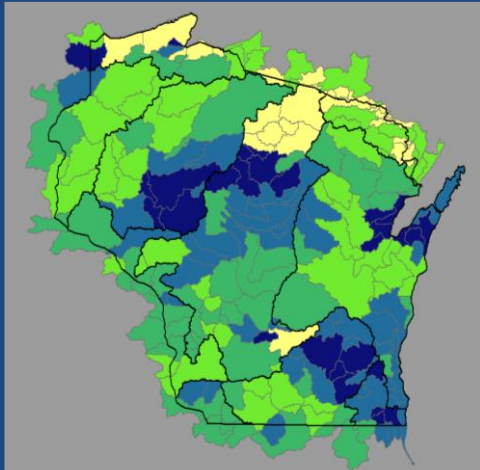
Top 10%		Bottom 10%	
WKEW3	49.6%	WI15C	0.06%
NMSW3	48.5%	WI14C	0.12%
BABW3	44.3%	WI13C	0.12%
RUSI2	42.9%	MRNM4	0.12%
TRIW3	41.9%	TWFM4	0.54%
RIBW3	40.0%	RRVW3	0.55%
PENW3	39.2%	VLCW3	0.63%
JFFW3	38.9%	LTKW3	0.64%
WI09C	38.9%	FLOW3	0.69%
WATW3	38.5%	BANM4	0.71%
WISW3	38.4%	CLKW3	0.73%
MILW3	38.2%	NIAW3	0.75%
HOWW3	38.0%	KFDW3	0.76%
OWNW3	38.0%	COMW3	0.78%
RRLW3	37.5%	KOSM4	0.88%
WMTW3	37.2%	BGQW3	1.02%
WI10C	37.2%	FLRW3	1.05%
SOSW3	37.0%	KNGW3	1.14%
FATW3	36.9%	WILW3	1.21%
KEWW3	36.6%	RHIW3	1.38%
WTLW3	36.4%	TKDW3	1.47%

Interflow Runoff Summary

- **Large range of Analysis Accumulated Interflow in the Study Basins**
  - *Lowest under 1mm for entire year. Largest basin value over 2100mm*

- **Generally highest amounts of interflow simulated in central Wisconsin**

- **Basins with lowest interflow generally along far northern Wisconsin**

- **Interflow is a key model component in determining Runoff Events and Risk**
  - *Must be present for an event to occur*
  - *Event accumulated interflow runoff is compared against threshold to determine risk*
  - *How much Interflow a basin produces is dependent on that basin's calibration*
  - *Anomalous basins with much lower interflow than neighbors poses a challenge*
    - **Not a simple adjustment to a threshold to increase or lower higher risk**

- **In general, Interflow is present around 20% of the time**

Data Analysis Overview

1. **The following model parameters were analyzed:**

   ➢ *Forecast Precipitation*   *(FMAP)*

   ➢ *Rain+Melt*   *(RAIM)*

   ➢ *SAC-SMA Interflow Runoff*   *(INTRO)*

   ➢ ***SAC-SMA Upper Zone Tension Water Deficit***   ***(UZTWD)***

2. **Analysis of Simulated Runoff Events**

   ➢ *Review Raw Simulated Events*
     - **Number of events , Amount of runoff, and Total Time per Risk Category**

   ➢ *Review in Boolean Perspective*
     - **Does period in question have at least one event = 1, otherwise = 0**

   ➢ *Review in Warning Day Perspective*
     - **Equivalent to RRAF map hosted by WI DATCP webpage**

   ➢ *Review in Runoff Type Perspective*
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

National Weather Service

Protecting Lives and Property
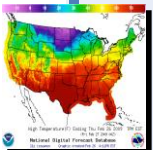
Upper Zone Tension Water Deficit (UZTWD)

➢ **UZTWD is simulated at every time-step in the forecast run**

➢ **Look for similar inconsistencies as forecast precipitation**

➢ **UZTWD = (UZTW Contents / UZTW Maximum)**
  ➢ *UZTW Contents has opportunity to increase or decrease every timestep*

➢ **Basins have different sized UZTW Maximum**
  ➢ *"bucket sizes" decided during calibration*
  ➢ *Different calibrators could decide on different values for similar basins*
  ➢ *Speed that basins can drain their UZTW bucket can also vary*

➢ **Runoff Event requires UZTWD = 0**
  ➢ *This requirement was added as first step to limit model false alarms*
  ➢ *Theoretically focuses risk on moments when nutrient contaminated runoff would be highest*

UZTWD

Legend (left map):
- ☐ < -1.5 Std. Dev.
- ☐ -1.5 - -0.50 Std. Dev.
- ☐ -0.50 - 0.50 Std. Dev.
- ☐ 0.50 - 1.5 Std. Dev.
- ☐ 1.5 - 2.5 Std. Dev.
- ☐ > 2.5 Std. Dev.

Legend (right map):
- ☐ 60,000 - 100,000
- ☐ 100,000 - 140,000
- ☐ 140,000 - 180,000
- ☐ 180,000 - 220,000
- ☐ 220,000 - 260,000
- ☐ 260,000 - 300,000
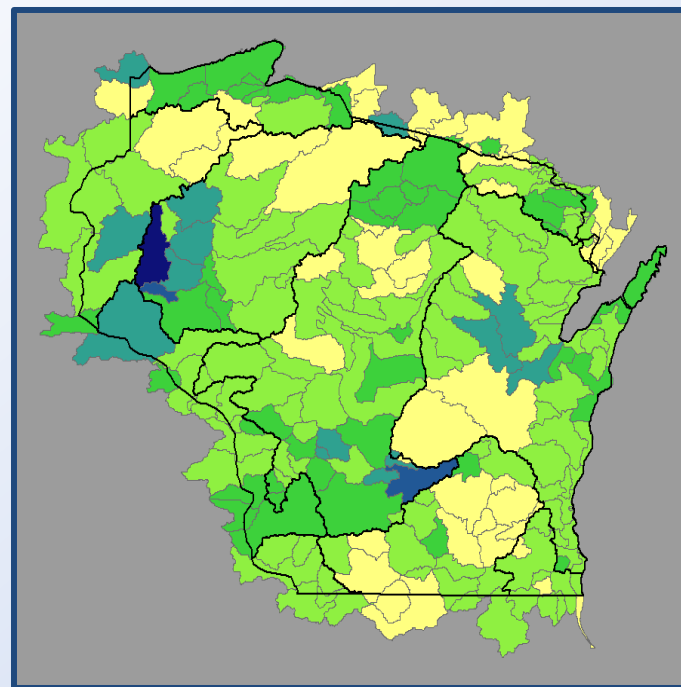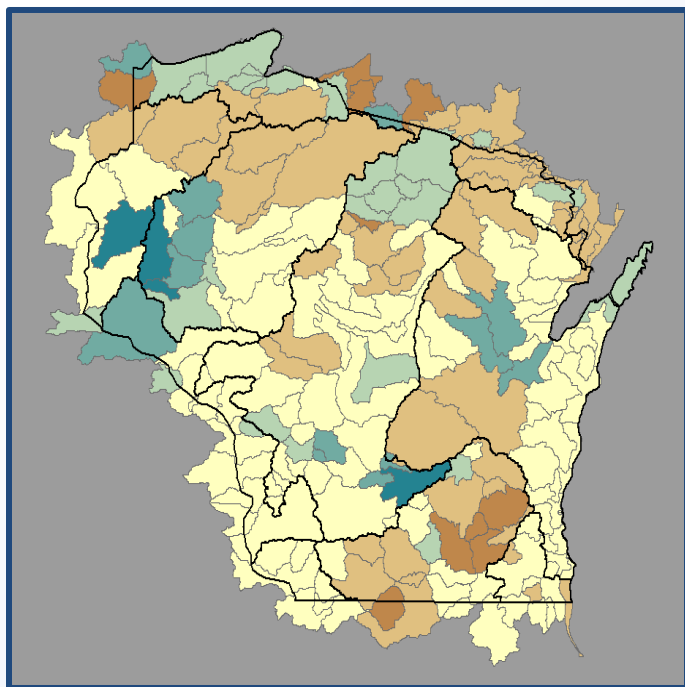
➢ **Total Accumulation of UZTWD values over the year**

➢ **No physical meaning to this summed value except as an indicator of the tendency for basins to build more or less of a deficit over time compared to other basins**

Median Time Step UZTWD Value

▢ (pale yellow)	0.5 - 2
▢ (light green)	2 - 4
▢ (green)	4 - 6
▢ (medium green)	6 - 8
▢ (teal green)	8 - 10
▢ (light blue)	10 - 12
▢ (blue)	12 - 14
▢ (dark navy)	14 - 16
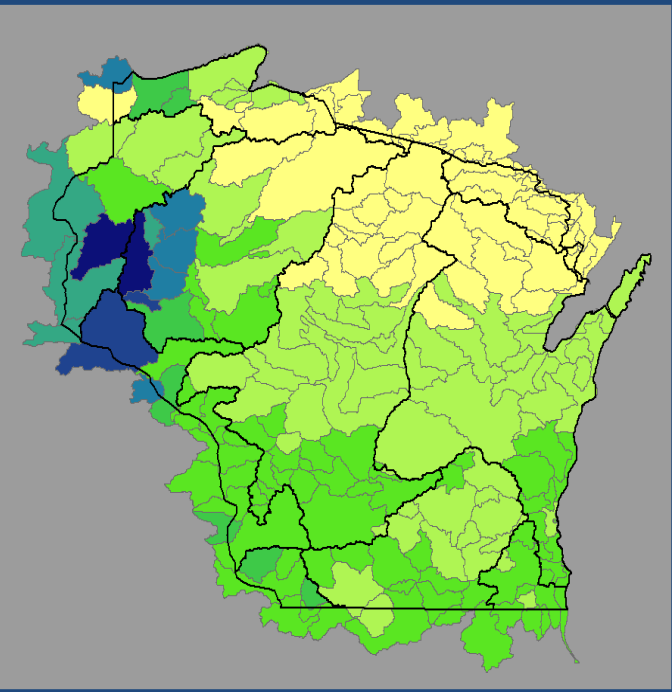
➤ **Analysis Accumulated Median Time Step UZTWD Value (mm)**

➤ **Smaller median deficits in northern basins**

➤ **Larger median deficits on western border over the test period**

▢ (tan)	< -0.50 Std. Dev.
▢ (pale yellow)	-0.50 - 0.50 Std. Dev.
▢ (sage green)	0.50 - 1.5 Std. Dev.
▢ (teal)	> 1.5 Std. Dev.
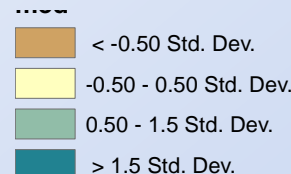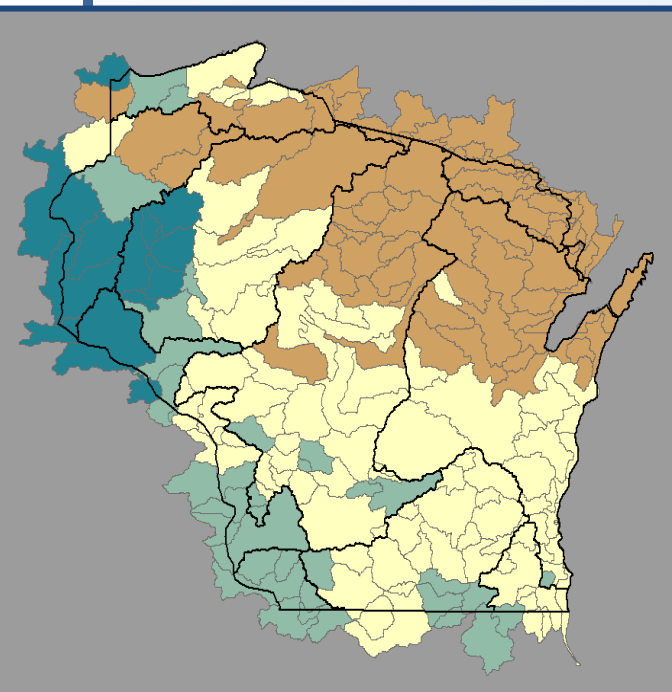
Percentage of Analysis Accumulated UZTWD Time Steps that were Zero or Non Zero

All Basins % of UZTWD Time Steps that were Zero or Non-Zero

	Zero	Non-Zero
Median ::	17%	83%
Max ::	43%	94%
Min ::	6%	57%

Percent Time UZTWD = 0

Percent Time UZTWD = 0

Legend (top map):
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.3 Std. Dev.
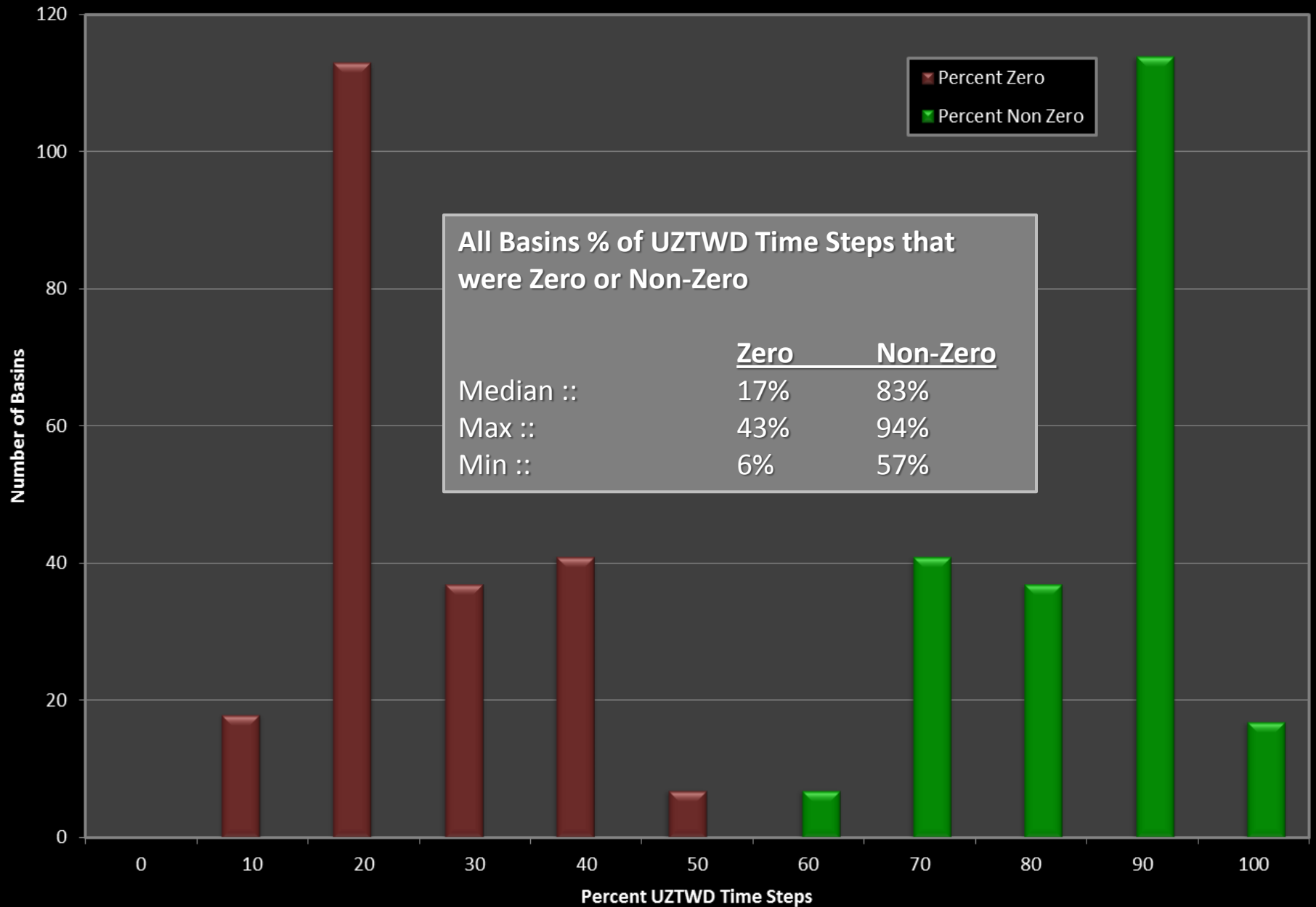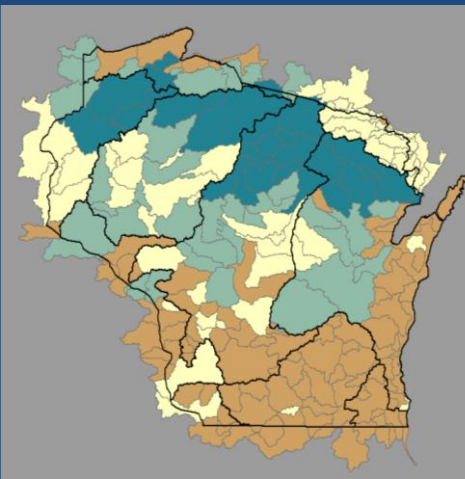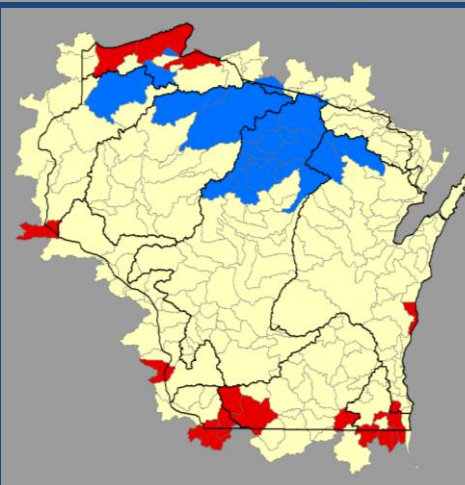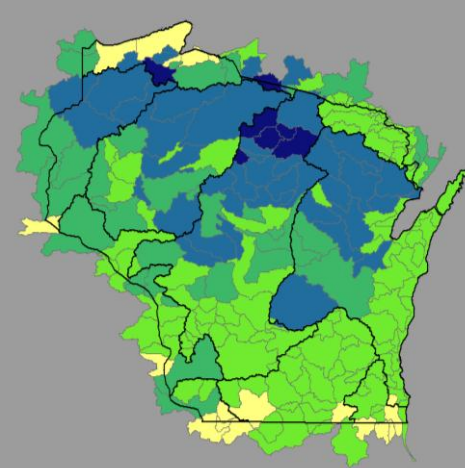
Top 10%		Bottom 10%	
RHIW3	42.9%	WI15C	6.0%
RRVW3	41.1%	WI13C	6.5%
WILW3	41.1%	WI14C	7.0%
TRIW3	41.1%	WI12C	7.3%
KNGW3	40.8%	CLIW3	8.2%
MRNM4	40.5%	NIPI2	8.3%
MASW3	40.4%	APRI2	8.3%
LTKW3	39.6%	RAYW3	8.3%
WTLW3	39.4%	RUSI2	8.6%
DANW3	39.3%	GLAI2	8.9%
OWNW3	39.3%	BUNW3	9.2%
CRIW3	39.0%	RDWM5	9.3%
RIBW3	38.7%	OMCI2	9.7%
BGFW3	38.6%	JHNI2	9.7%
LGLW3	38.4%	GUNI2	9.8%
TKDW3	38.3%	BLVI4	9.9%
RRLW3	38.0%	MTNW3	9.9%
SPDW3	37.8%	MCGI4	10%
MRLW3	37.7%	WI05C	10.2%
WERW3	37.3%	DARW3	10.3%
KELW3	37.2%	NMSW3	10.4%

UZTWD Summary

➤ **Similar to Interflow Runoff, UZTWD is dependent on basin calibration**

➤ **Generally across Wisconsin, higher deficits exist across the western border and lower deficits exist in northeastern Wisconsin**

➤ **Overall UZTWD = 0 (Saturated conditions) exist 17% of the time**
   ➤ *A maximum of 43% and a minimum of 6% of the time*

➤ **Basins that have the highest percentage of time with UZTWD = 0 are found in the headwaters of the Wisconsin and Chippewa Rivers**

Data Analysis Overview

1. **The following model parameters were analyzed:**
   - *Forecast Precipitation*   *(FMAP)*
   - *Rain+Melt*   *(RAIM)*
   - *SAC-SMA Interflow Runoff*   *(INTRO)*
   - *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**
   - ***Review Raw Simulated Events***
     - **Number of events , Amount of runoff, and Total Time per Risk Category**

   - *Review in Boolean Perspective*
     - **Does period in question have at least one event = 1, otherwise = 0**

   - *Review in Warning Day Perspective*
     - **Equivalent to RRAF map hosted by WI DATCP webpage**

   - *Review in Runoff Type Perspective*
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

Analysis Accumulated Number of Simulated Runoff Events

All Basins Runoff Events Statistics

	ALL	C2	C3
Median ::	198	83	114
Max ::	287	153	176
Min ::	9	8	1
Sum ::	40,389	17,569	22,820

C2 Events
C3 Events
All Events

Number of Basins

Basin Simulated Events

Analysis Accumulated Simulated Runoff Events

	0
	1 - 20
	21 - 40
	41 - 60
	61 - 80
	81 - 100
	101 - 120
	121 - 140
	141 - 160
	161 - 180
	181 - 200
	201 - 220
	221 - 240
	241 - 260
	261 - 280
	281 - 300
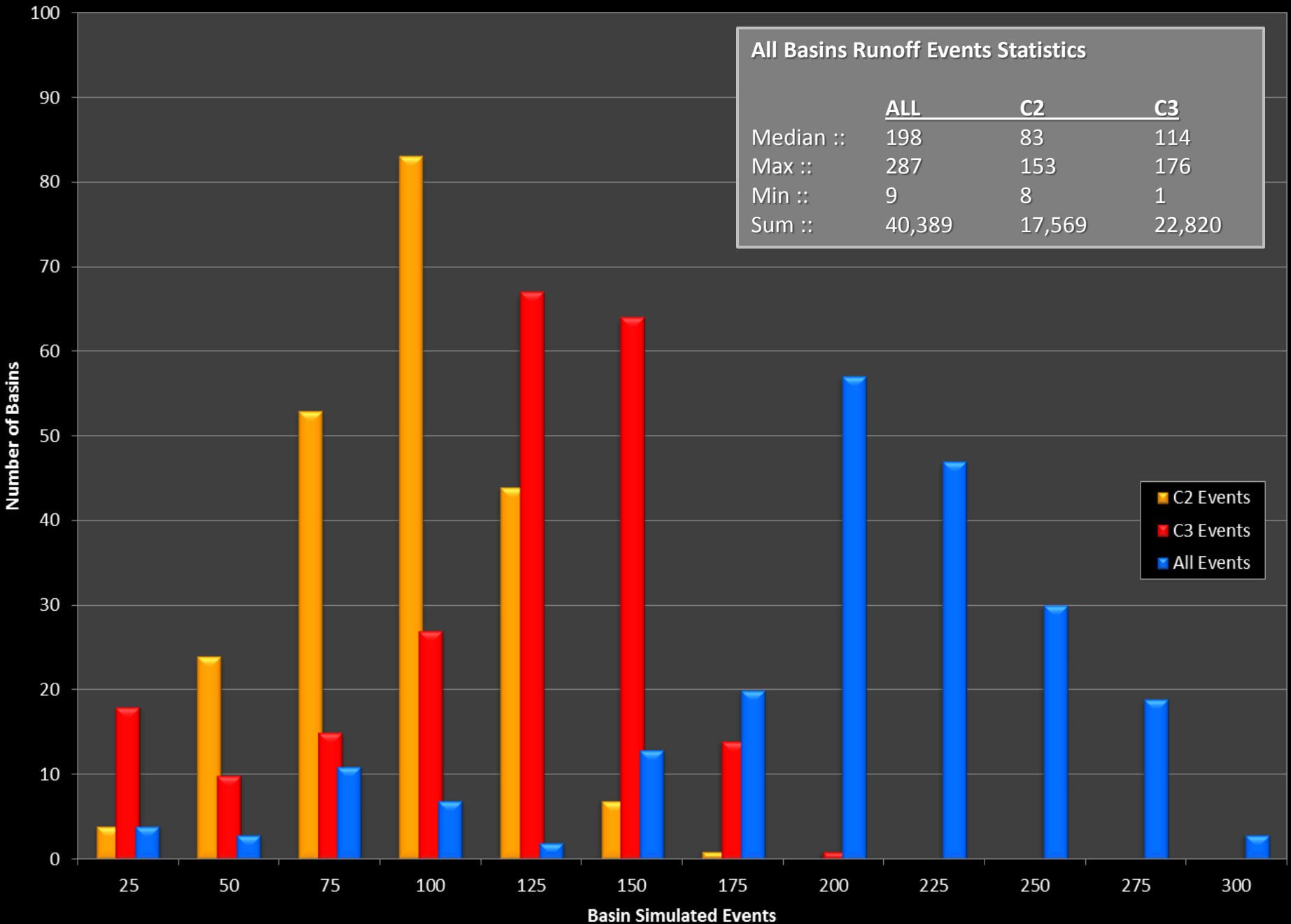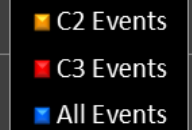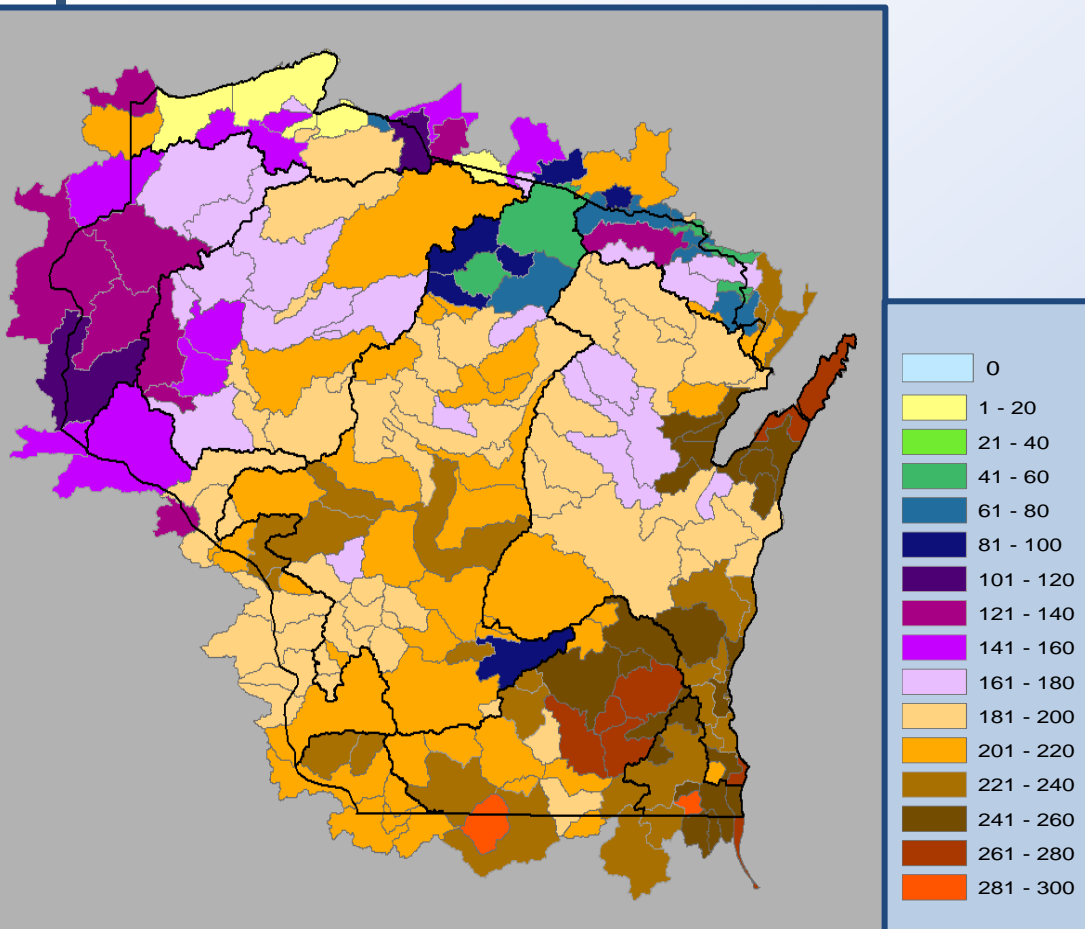
➢ **This is a sum of all C2 and C3 events for each basin**

➢ **Focus will be on smoothing out outlier basins and evaluating drastic transitions**

➢ **Outlier Basins::**

  ➢ *Are they due to basin calibration?*

  ➢ *Are there hydrological reasons for a difference?*

Stratifying Total Number of Simulated Runoff Events
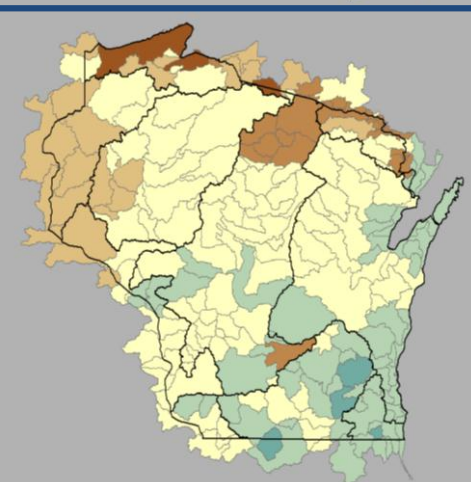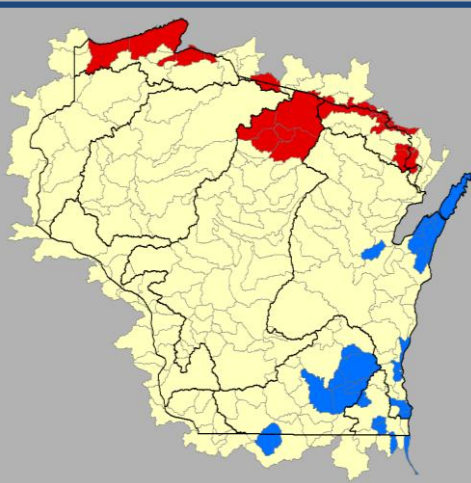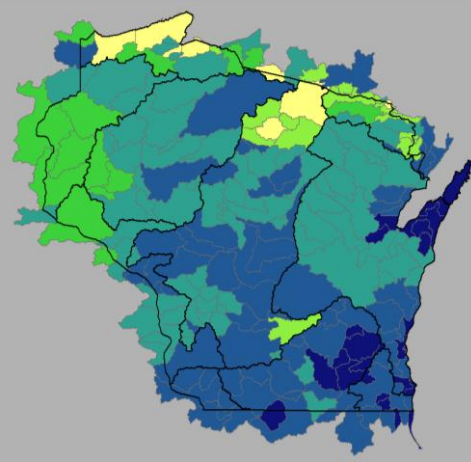
Top 10%		Bottom 10%	
FEEI2	287	WI15C	9
WMTW3	287	WI13C	10
FATW3	276	WI14C	12
WATW3	275	MRNM4	14
JFFW3	267	TWFM4	45
INFW3	266	RRVW3	45
WI02C	265	LTKW3	49
IL02C	263	VLCM4	51
WI08C	261	BANM4	51
HUSW3	257	FLOW3	53
NMSW3	257	CLKW3	53
KEWW3	256	NIAW3	60
RACW3	255	WI12C	62
ROMW3	255	COMW3	63
WI07C	255	KOSM4	64
OMCI2	253	KFDM4	64
HOWW3	252	FLRW3	69
MISW3	252	KNGW3	70
WI04C	252	BGQW3	79
MEEW3	251	RHIW3	81
MUKW3	251	WILW3	82

Analysis Accumulated Total Number of Simulated Runoff Events by Category

Analysis Accumulated C2 Events
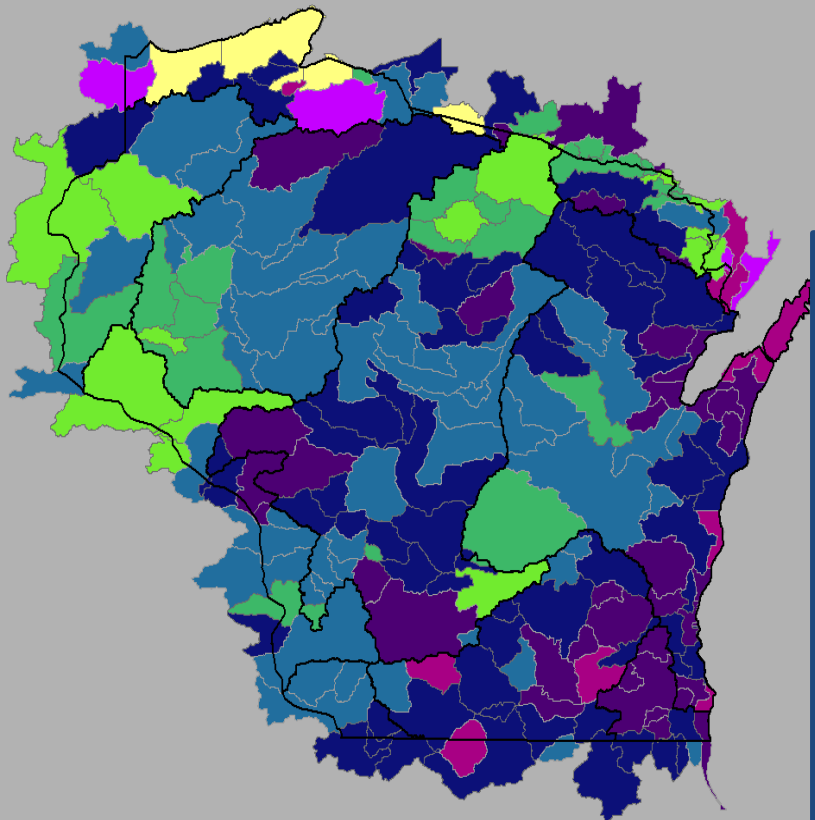
Analysis Accumulated C3 Events

	0
	1 - 20
	21 - 40
	41 - 60
	61 - 80
	81 - 100
	101 - 120
	121 - 140
	141 - 160
	161 - 180
	181 - 200
	201 - 220
	221 - 240
	241 - 260
	261 - 280
	281 - 300
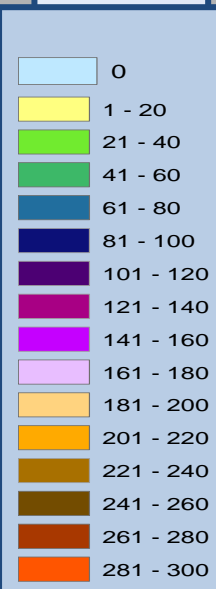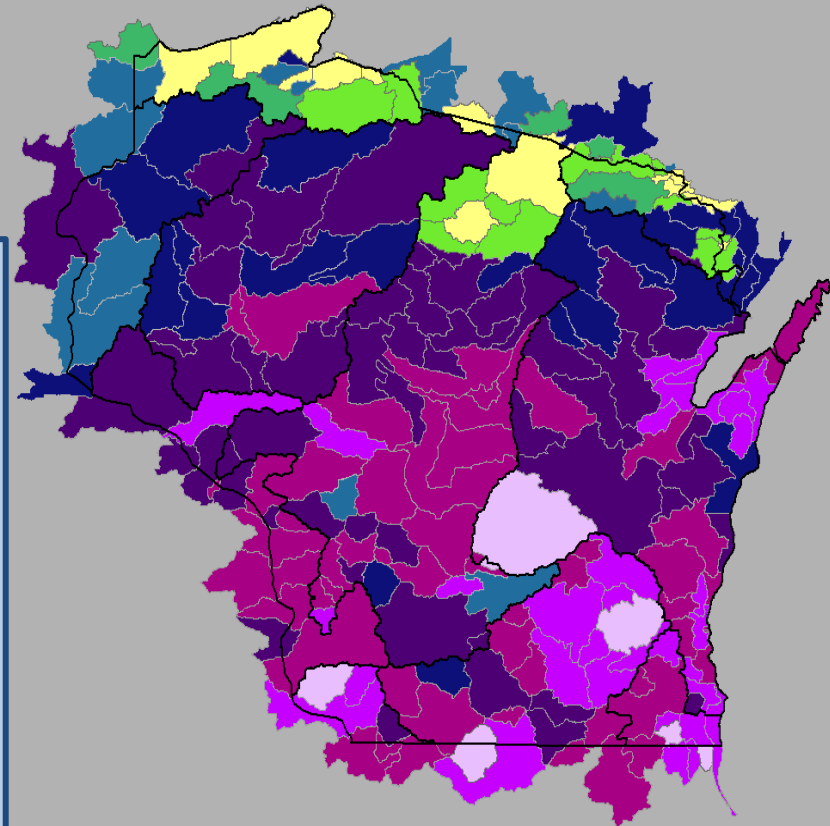
Stratifying Total Number of Simulated C2 Runoff Events

| 1 - 30 |
| 31 - 60 |
| 61 - 90 |
| 91 - 120 |
| 121 - 150 |
| 151 - 180 |

| 0 - 10% Exceedance |
| 10 - 90% Exceedance |
| 90 - 100% Exceedance |

| < -2.5 Std. Dev. |
| -2.5 - -1.5 Std. Dev. |
| -1.5 - -0.50 Std. Dev. |
| -0.50 - 0.50 Std. Dev. |
| 0.50 - 1.5 Std. Dev. |
| 1.5 - 2.5 Std. Dev. |
| > 2.5 Std. Dev. |
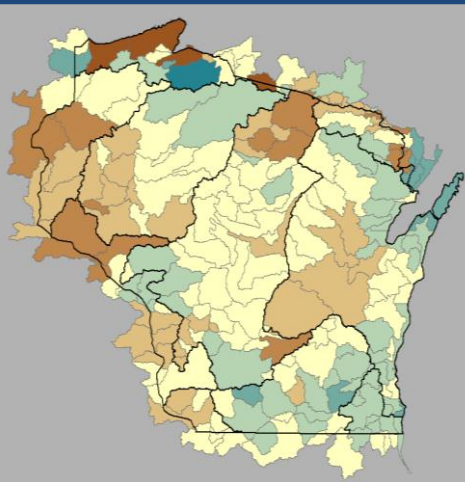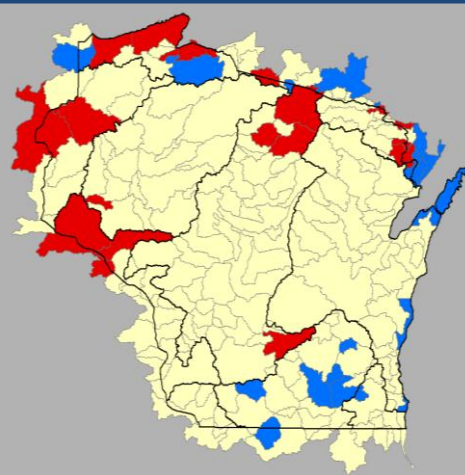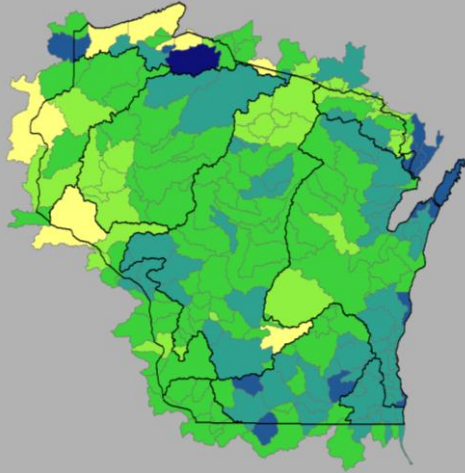
Top 10%		Bottom 10%	
ODAW3	153	WI15C	8
GRRW3	144	WI13C	8
MI33C	141	WI14C	10
SOSW3	141	MRNM4	10
WI08C	138	SCFW3	26
WHRW3	132	PDSW3	28
MCAW3	131	WABM5	30
SCUW3	127	RRVW3	31
BCHW3	125	LTKW3	31
FATW3	122	CLKW3	32
WI02C	122	BANM4	33
FEEI2	121	MENW3	34
WI05C	121	ALMW3	35
MUKW3	118	TWFM4	36
JFFW3	117	VLCM4	37
HUSW3	116	MSCM5	37
CRYM4	115	GTBW3	37
ORCM4	115	FLOW3	37
WI04C	115	KOSM4	39
MFSM4	114	KNGW3	41
INFW3	113	WI12C	42

Stratifying Total Number of C3 Simulated Runoff Events

| 1 - 30 |
| 31 - 60 |
| 61 - 90 |
| 91 - 120 |
| 121 - 150 |
| 151 - 180 |

| 0 - 10% Exceedance |
| 10 - 90% Exceedance |
| 90 - 100% Exceedance |

| < -2.5 Std. Dev. |
| -2.5 - -1.5 Std. Dev. |
| -1.5 - -0.50 Std. Dev. |
| -0.50 - 0.50 Std. Dev. |
| 0.50 - 1.5 Std. Dev. |
| 1.5 - 1.8 Std. Dev. |
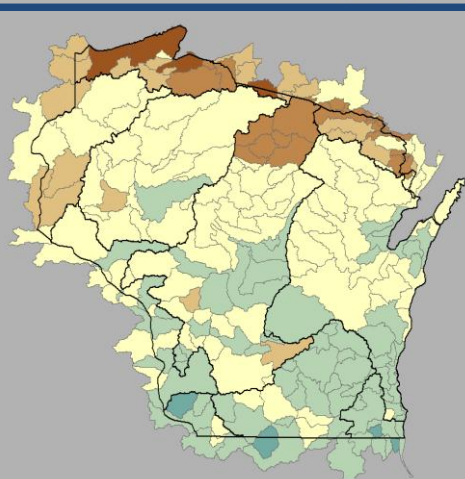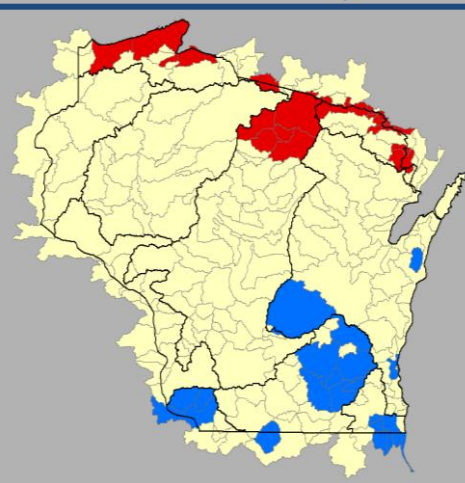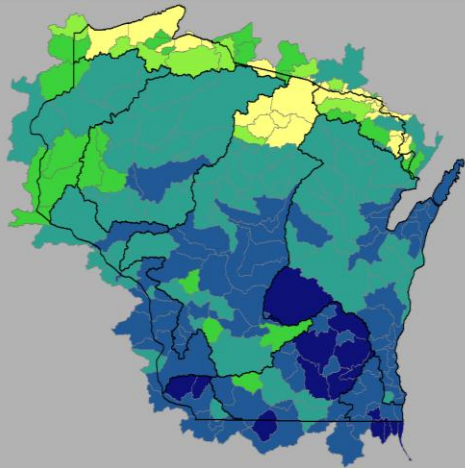
Top 10%		Bottom 10%	
WMTW3	176	WI15C	1
GUNI2	170	WI14C	2
BTNW3	167	WI13C	2
FEEI2	166	MRNM4	4
BERW3	164	TWFM4	9
WATW3	164	VLCM4	14
MILW3	160	RRVW3	14
ROMW3	160	NIAW3	16
RVLW3	160	FLOW3	16
HCNW3	159	KFDM4	17
OMCI2	159	LTKW3	18
IL02C	158	BANM4	18
JHNI2	156	WI12C	20
FATW3	154	COMW3	21
INFW3	153	CLKW3	21
JFFW3	150	BGQW3	22
DBQI4	149	FLRW3	24
RUSI2	149	KOSM4	25
MEEW3	148	WILW3	29
NMSW3	148	RHIW3	29
MISW3	147	KNGW3	29

Percent Analysis Accumulated Simulated Runoff Events by Category

All Basins Percent Runoff
Events by Category

	% C2	% C3
Median ::	43	57
Max ::	89	81
Min ::	19	11

Stratifying Percent Total Events That Are C2

0 - 20
20 - 40
40 - 60
60 - 80
80 - 100

Percent All Events That Are C2

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.
> 2.5 Std. Dev.
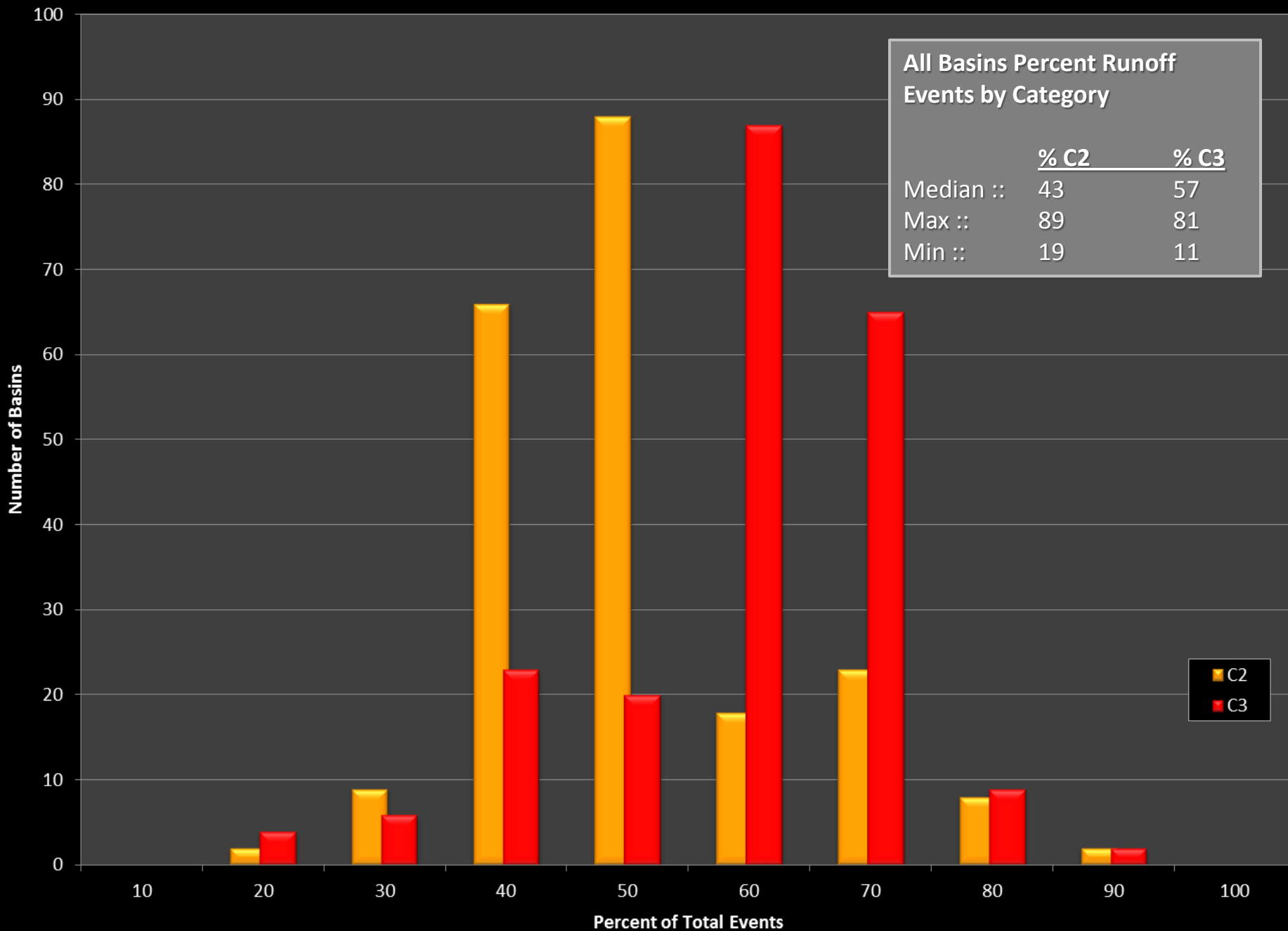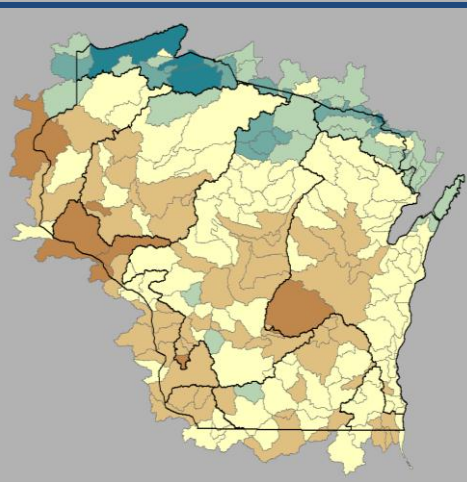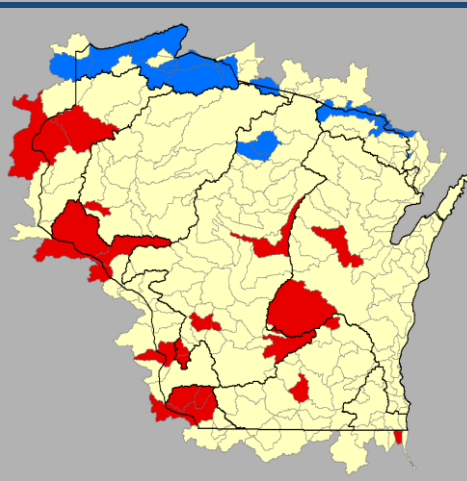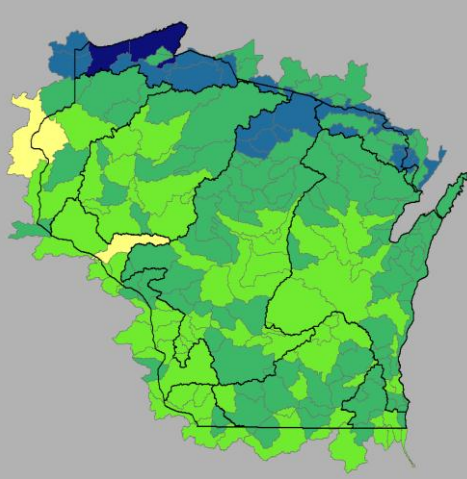
Top 10%		Bottom 10%	
WI15C	88.9%	ALMW3	19.3%
WI14C	83.3%	SCFW3	19.6%
TWFM4	80.0%	WABM5	20.4%
WI13C	80.0%	MENW3	25.2%
ODAW3	76.7%	BERW3	25.5%
KFDM4	73.4%	MSCM5	26.4%
NIAW3	73.3%	STEW3	26.6%
VLCM4	72.6%	GTBW3	28.0%
BGQW3	72.2%	BTNW3	28.6%
MRNM4	71.4%	HILW3	29.3%
FLOW3	69.8%	DBQI4	29.7%
MRSW3	69.5%	GUNI2	30.3%
RRVW3	68.9%	NEWW3	30.6%
WI12C	67.7%	PDSW3	31.5%
WHRW3	67.7%	RVLW3	31.6%
SOSW3	67.1%	LYNW3	31.8%
COMW3	66.7%	LAFW3	32.1%
MASW3	66.4%	FULW3	32.2%
FLRW3	65.2%	GMIW3	32.5%
TKDW3	64.8%	WIRW3	32.8%
BANM4	64.7%	WPNW3	33.0%

Stratifying Percent Total Events That Are C3

0 - 20
20 - 40
40 - 60
60 - 80
80 - 100

Percent All Events That Are C3

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -2.5 Std. Dev.
-2.5 - -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.1 Std. Dev.
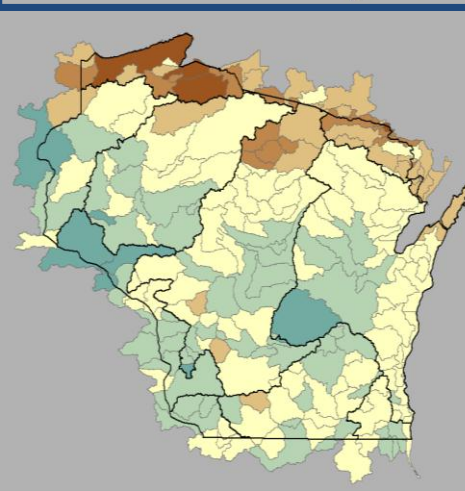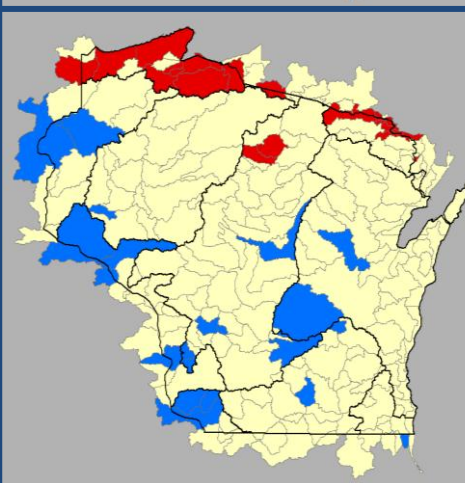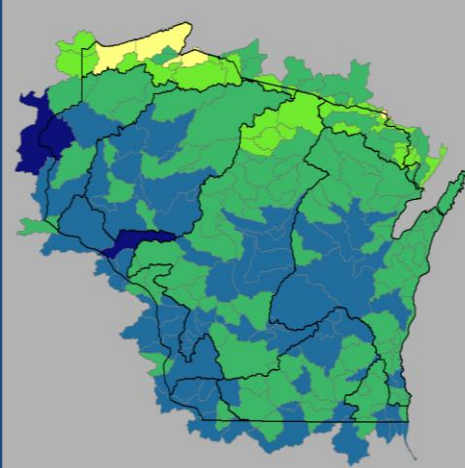
Top 10%		Bottom 10%	
ALMW3	80.7%	WI15C	11.1%
SCFW3	80.5%	WI14C	16.7%
WABM5	79.6%	TWFM4	20.0%
MENW3	74.8%	WI13C	20.0%
BERW3	74.6%	ODAW3	20.3%
MSCM5	73.6%	KFDM4	26.6%
STEW3	73.4%	NIAW3	26.7%
GTBW3	72.0%	VLCM4	27.5%
BTNW3	71.4%	BGQW3	27.9%
HILW3	70.7%	MRNM4	28.6%
DBQI4	70.3%	FLOW3	30.2%
GUNI2	69.7%	MRSW3	30.5%
NEWW3	69.4%	RRVW3	31.1%
PDSW3	68.5%	WI12C	32.3%
RVLW3	68.4%	WHRW3	32.3%
LYNW3	68.3%	SOSW3	32.9%
LAFW3	67.9%	COMW3	33.3%
FULW3	67.8%	MASW3	33.6%
GMIW3	67.6%	FLRW3	34.8%
WIRW3	67.2%	TKDW3	35.2%
WPNW3	67.0%	BANM4	35.3%

Number of Runoff Events Summary

➢ **Median number of runoff events for a basin = 198**

  ➢ *All Events :: Max is 287 events and minimum is only 9*

  ➢ *C2 :: Median = 83, Max = 153, Min = 8*

  ➢ *C3 :: Median = 114, Max = 176, Min = 1*

➢ **Generally more events in a basin were High Risk (C3)**

  ➢ *Medium risk (C2) is generally 43% of events in a basin*

  ➢ *High risk (C3) is generally 57% of events in a basin*

➢ **Southern third of Wisconsin is home to highest number of events**

  ➢ *Several basins stick out as outliers when viewing spatially*

➢ **Highest percentage of events in a basin that are C2 is on far northern basins**

  ➢ *These same basins are lowest in percentage of C3 (High Risk)*

Data Analysis Overview

1. **The following model parameters were analyzed:**

   - *Forecast Precipitation*   *(FMAP)*
   - *Rain+Melt*   *(RAIM)*
   - *SAC-SMA Interflow Runoff*   *(INTRO)*
   - *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**

   - ***Review Raw Simulated Events***
     - **Number of events , Amount of runoff, and Total Time per Risk Category**

   - *Review in Boolean Perspective*
     - **Does period in question have at least one event = 1, otherwise = 0**

   - *Review in Warning Day Perspective*
     - **Equivalent to RRAF map hosted by WI DATCP webpage**

   - *Review in Runoff Type Perspective*
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

National Weather Service

Protecting Lives and Property
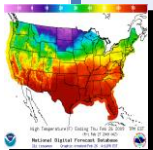
Analysis Accumulated Total Simulated Event Runoff

C2

C3

All

Legend:
- 0 mm
- 0 - 100 mm
- 100 - 200 mm
- 200 - 300 mm
- 300 - 400 mm
- 400 - 500 mm
- 500 - 600 mm
- 600 - 700 mm
- 700 - 800 mm
- 800 - 900 mm
- 900 - 1000 mm
- 1000 - 1100 mm
- 1100 - 1200 mm
- 1200 - 1300 mm
- 1300 - 1400 mm
- 1400 - 1500 mm
- 1500 - 1600 mm

➤ **Analysis Accumulated Event Runoff in mm**

➤ **Thresholds appear to focus emphasis on High Risk Events (C3) as Medium Risk accumulations are uniformly small (100mm or less)**

➤ **Dramatic Range of Analysis Accumulated Event Runoff from less than 0.1 to over 1500 mm**

➤ **Some Obvious Outliers appear**

➤ **Remember Event Runoff is the sum of Interflow Runoff when all event criteria conditions are met**

   ➤ *Interflow RO >= Event Runoff*
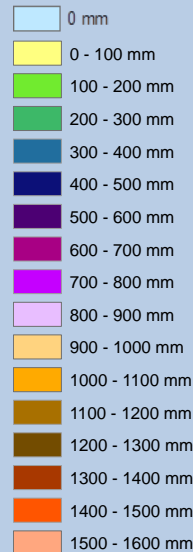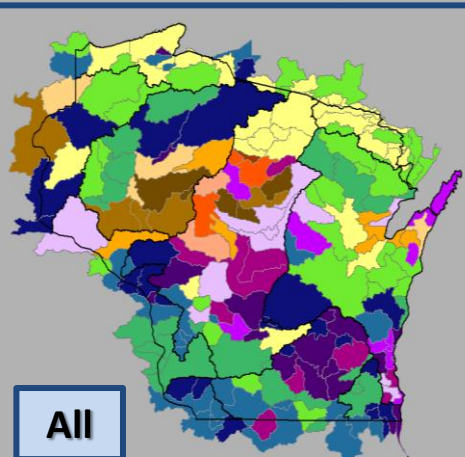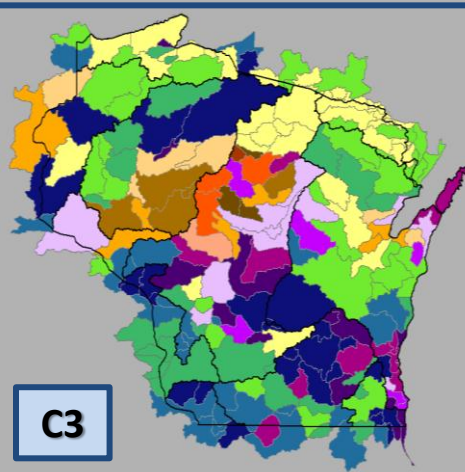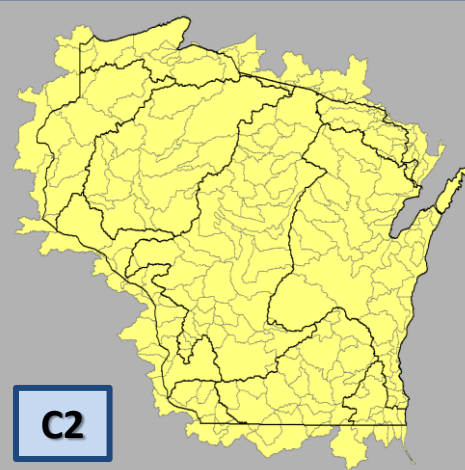
Stratifying Total Analysis Accumulated Event Runoff

Legend (top map):
- 0.63 - 250
- 250 - 500
- 500 - 750
- 750 - 1000
- 1000 - 1250
- 1250 - 1586.55

Total Simulated Event Runoff (mm)

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.
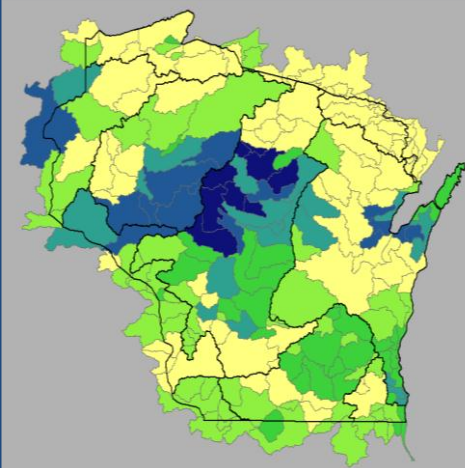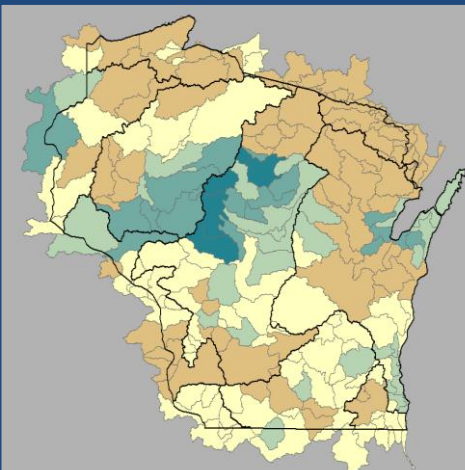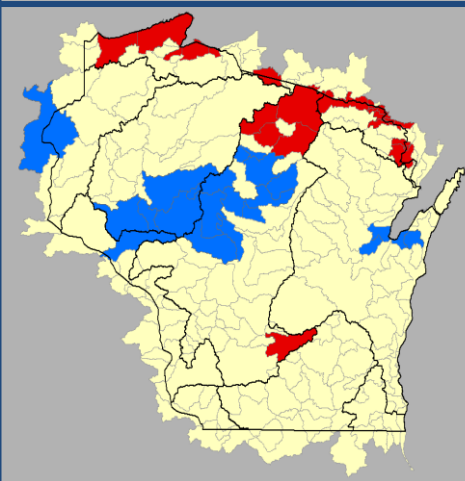
Top 10%		Bottom 10%	
HATW3	1587	WI15C	0.63
OWNW3	1502	WI13C	0.90
NEIW3	1482	WI14C	0.97
RRLW3	1480	MRNM4	1.8
TRIW3	1441	TWFM4	6.8
SPDW3	1333	RRVW3	9.0
EPLW3	1290	VLCM4	10.2
STRW3	1279	LTKW3	11.2
WUUW3	1252	BANM4	12.4
WISW3	1207	FLOW3	12.6
THOW3	1203	CLKW3	13.1
FLCW3	1192	KFDM4	13.2
DURW3	1186	NIAW3	13.5
ROTW3	1121	COMW3	14.3
SCFW3	1103	WI12C	18.6
ECLW3	1102	KOSM4	19.1
HOWW3	1090	BGQW3	19.4
WI09C	1084	FLRW3	19.7
ALMW3	1069	WILW3	22.1
BBCW3	1050	KNGW3	27.6
KEWW3	1021	PDSW3	30.4

Stratifying C2 Analysis
Accumulated Event Runoff

0.28 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 65

C2 Simulated Event Runoff (mm)

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.
> 2.5 Std. Dev.
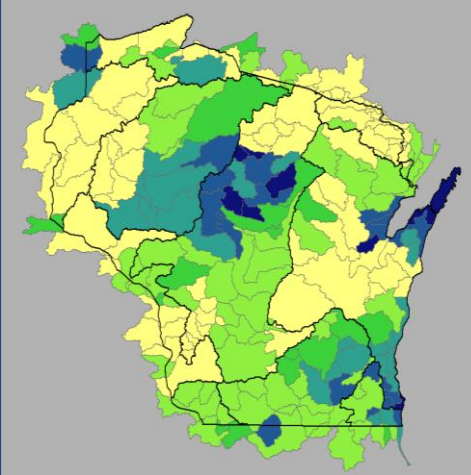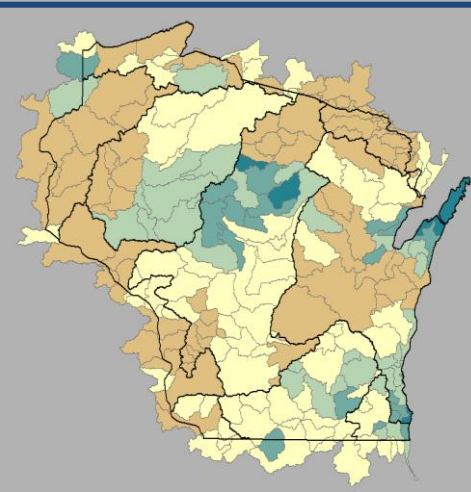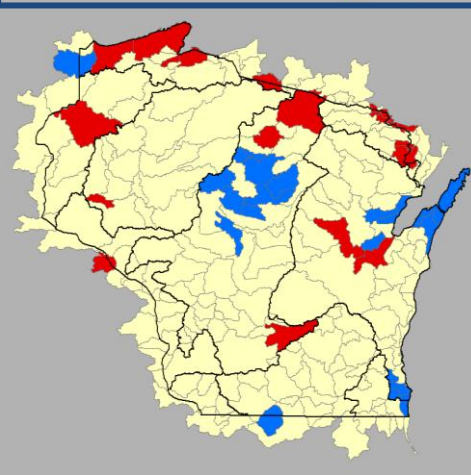
Top 10%		Bottom 10%	
SPDW3	64.9	WI15C	0.28
WI08C	63.8	WI13C	0.29
TRIW3	61.3	WI14C	0.42
WI02C	59.3	MRNM4	0.67
WUUW3	58.2	PDSW3	1.1
STRW3	55.9	TWFM4	2.1
HOWW3	55.2	MENW3	2.4
EPLW3	53.1	COMW3	2.4
BBCW3	49.4	LTKW3	2.4
RRLW3	48.8	GBYW3	2.4
SOSW3	48.6	NEWW3	2.5
WI10C	48.2	FLOW3	2.5
RACW3	47.5	CLKW3	2.5
ROTW3	47.2	MSCM5	2.5
RAYW3	46.8	GTBW3	2.6
WI07C	46.2	VLCM4	2.6
WI01C	45.2	RRVW3	2.8
PENW3	44.7	BANM4	2.8
OWNW3	44.4	NIAW3	2.9
FEEI2	44.2	KFDW3	2.9
FRKW3	43.9	KOSM4	2.9

Stratifying C3 Analysis Accumulated Event Runoff

Legend (top map):
- 0.35 - 100
- 100 - 250
- 250 - 500
- 500 - 750
- 750 - 1000
- 1000 - 1547.85

C3 Simulated Event Runoff (mm)

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.
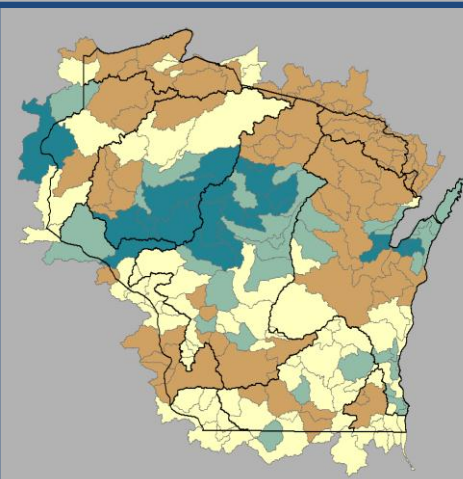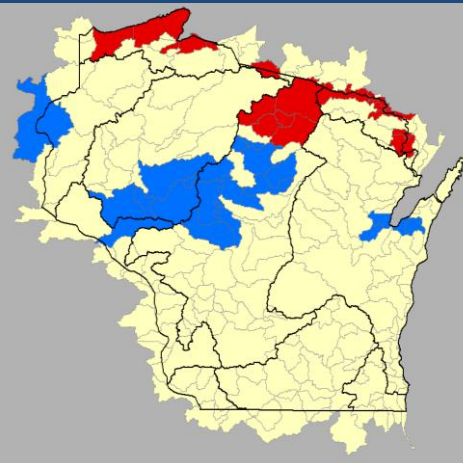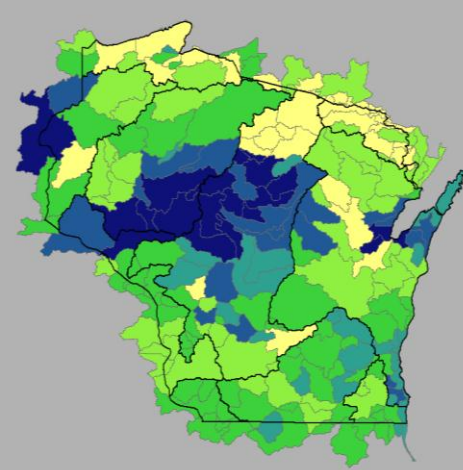
Top 10%		Bottom 10%	
HATW3	1548	WI15C	0.35
OWNW3	1457	WI14C	0.55
NEIW3	1438	WI13C	0.61
RRLW3	1431	MRNM4	1.1
TRIW3	1380	TWFM4	4.7
SPDW3	1268	RRVW3	6.2
EPLW3	1237	VLCM4	7.6
STRW3	1223	LTKW3	8.8
WUUW3	1194	BANM4	9.6
THOW3	1172	FLOW3	10.1
WISW3	1172	KFDM4	10.3
FLCW3	1158	CLKW3	10.6
DURW3	1154	NIAW3	10.7
SCFW3	1096	COMW3	11.9
ROTW3	1074	WI12C	15.6
ECLW3	1064	BGQW3	16.1
ALMW3	1063	KOSM4	16.2
WI09C	1044	FLRW3	16.7
HOWW3	1035	WILW3	17.6
BBCW3	1001	KNGW3	24.1
KEWW3	982	RHIW3	27.2

Percent Analysis Accumulated Simulated Event Runoff by Category
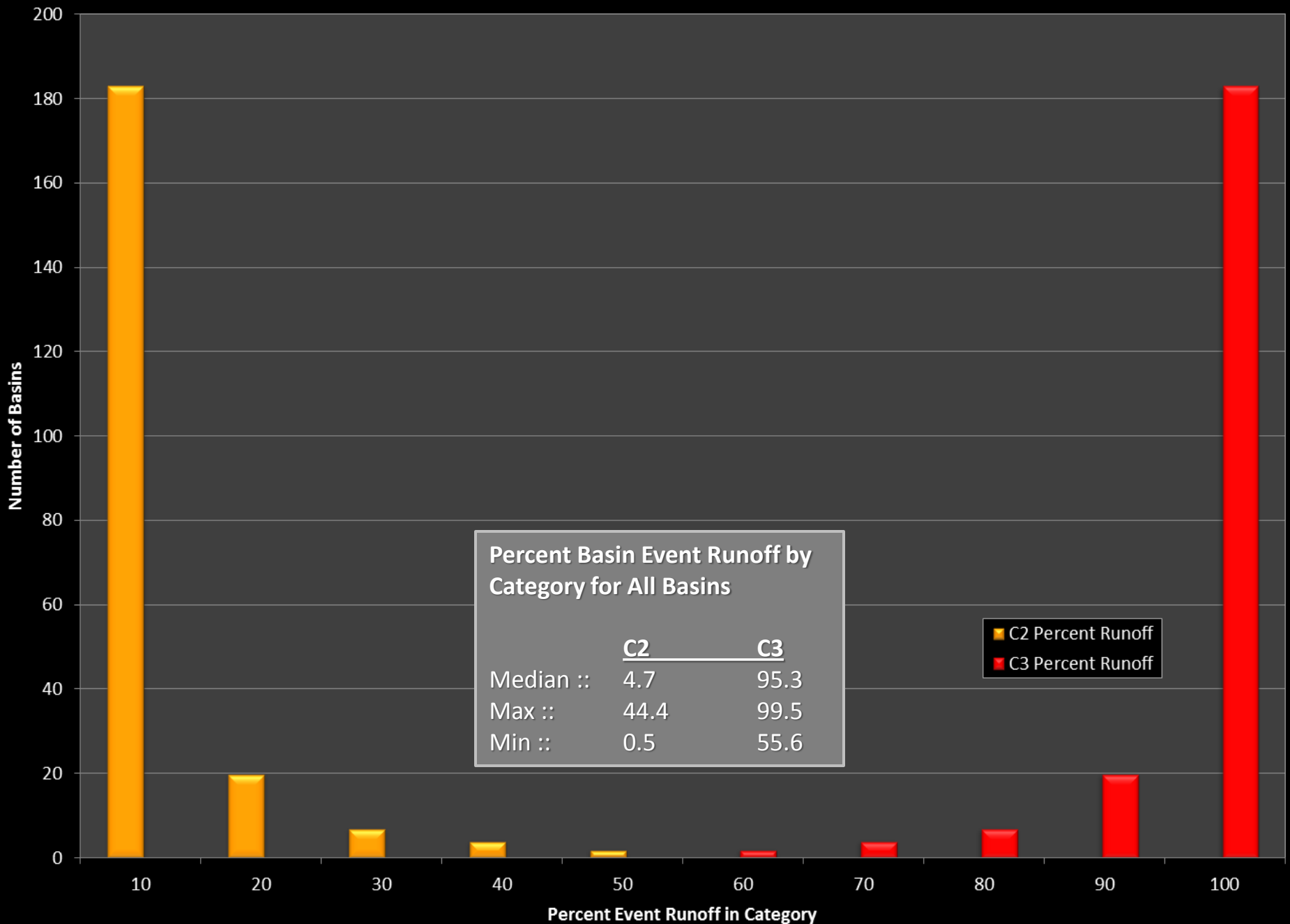
Percent Basin Event Runoff by Category for All Basins

	C2	C3
Median ::	4.7	95.3
Max ::	44.4	99.5
Min ::	0.5	55.6

- C2 Percent Runoff
- C3 Percent Runoff

Number of Basins

Percent Event Runoff in Category

Stratifying Percent Analysis
Accumulated Event Runoff That Was C2

0.52 - 10%
10 - 20%
20 - 30%
30 - 40%
40 - 50%

Percent Event Runoff = C2

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
> 1.5 Std. Dev.
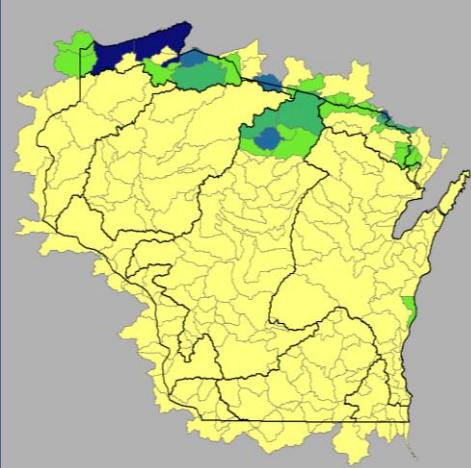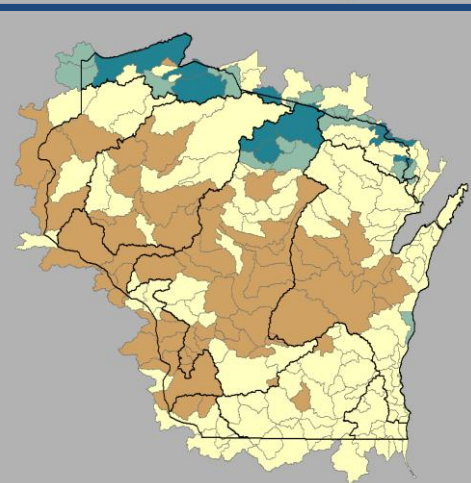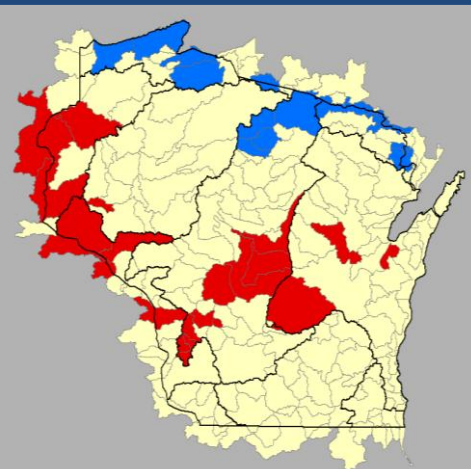
Top 10%		Bottom 10%	
WI15C	44.4%	ALMW3	0.5%
WI14C	43.3%	WABW3	0.6%
MRNM4	37.9%	GTBW3	0.6%
WI13C	32.2%	SCFW3	0.7%
RRVW3	30.9%	BERW3	0.9%
TWFM4	30.8%	MENW3	1.0%
VLCM4	25.7%	LAFW3	1.1%
BANM4	22.7%	STEW3	1.5%
ODAW3	21.9%	NLSW3	1.7%
KFDM4	21.9%	MSCM5	1.8%
LTKW3	21.2%	NEWW3	1.9%
NIAW3	21.1%	CROW3	1.9%
WILW3	20.4%	WIRW3	1.9%
FLOW3	19.8%	PETW3	2.0%
CLKW3	19.1%	SOGW3	2.0%
BGQW3	17.0%	GMIW3	2.0%
COMW3	16.5%	REAW3	2.1%
WI12C	15.8%	HILW3	2.1%
FLRW3	15.4%	GREW3	2.1%
KOSM4	15.2%	BRWM5	2.2%
TKDW3	14.8%	PREW3	2.2%

Stratifying Percent Analysis
Accumulated Event Runoff That Was C3

55 - 60%
60 - 70%
70 - 80%
80 - 90%
90 - 100%

Percent Event Runoff = C3

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -2.5 Std. Dev.
-2.5 - -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 0.91 Std. Dev.
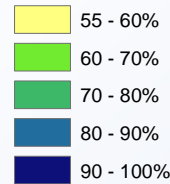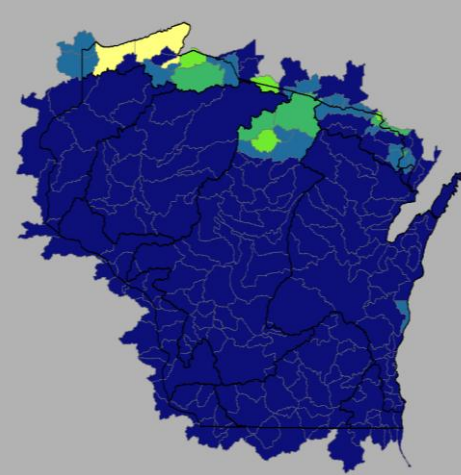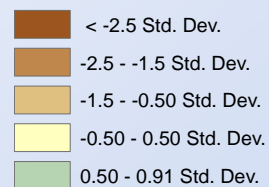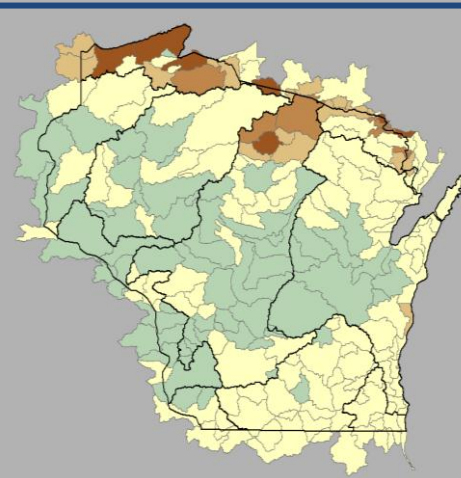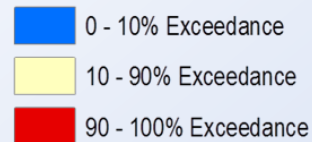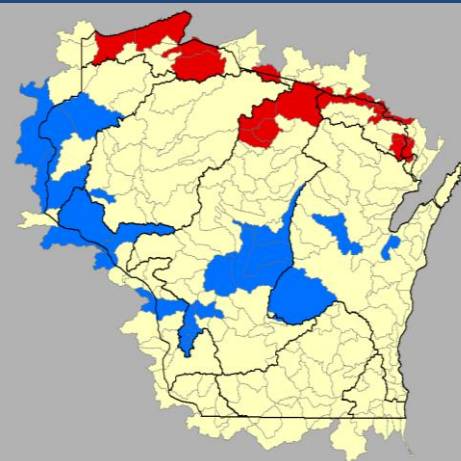
Top 10%		Bottom 10%	
ALMW3	99.5%	WI15C	55.6%
WABW3	99.4%	WI14C	56.7%
GTBW3	99.4%	MRNM4	62.2%
SCFW3	99.3%	WI13C	67.8%
BERW3	99.1%	RRVW3	69.1%
MENW3	99.0%	TWFM4	69.2%
LAFW3	98.9%	VLCM4	74.3%
STEW3	98.5%	BANM4	77.3%
NLSW3	98.3%	ODAW3	78.1%
MSCM5	98.2%	KFDM4	78.1%
NEWW3	98.1%	LTKW3	78.8%
CROW3	98.1%	NIAW3	78.9%
WIRW3	98.1%	WILW3	79.6%
PETW3	98.0%	FLOW3	80.3%
SOGW3	98.0%	CLKW3	80.9%
GMIW3	98.0%	BGQW3	83.0%
REAW3	97.9%	COMW3	83.5%
HILW3	97.9%	WI12C	84.2%
GREW3	97.9%	FLRW3	84.6%
BRWM5	97.9%	KOSM4	84.8%
PREW3	97.9%	TKDW3	85.2%

Comparing Simulated Event Runoff to Total Available Interflow Runoff for a Basin

Legend:
- 0.0
- 0 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000
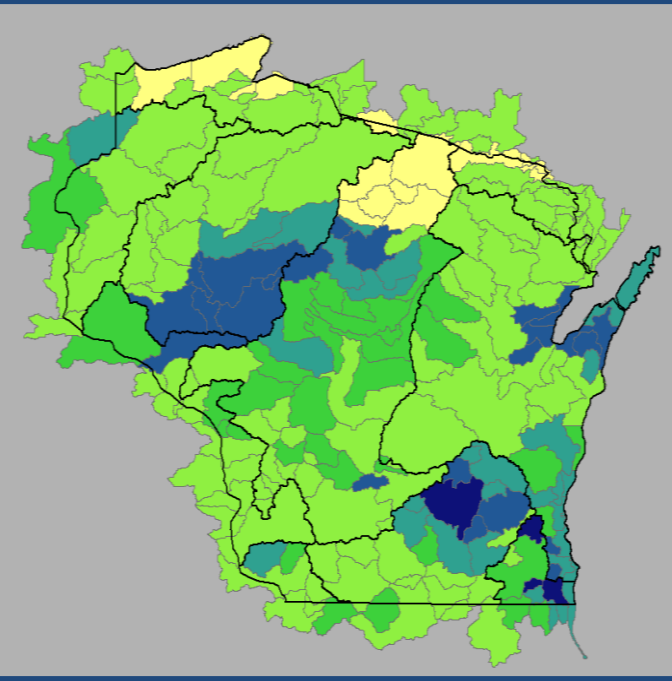
**Analysis Accumulated
(Total Interflow - Simulated Event Runoff)
(mm) (All Events)**

Legend:
- 32 - 40%
- 40 - 50%
- 50 - 60%
- 60 - 70%
- 70 - 80%
- 80 - 90%
- 90 - 100%
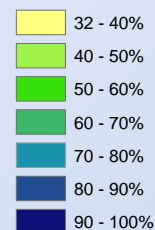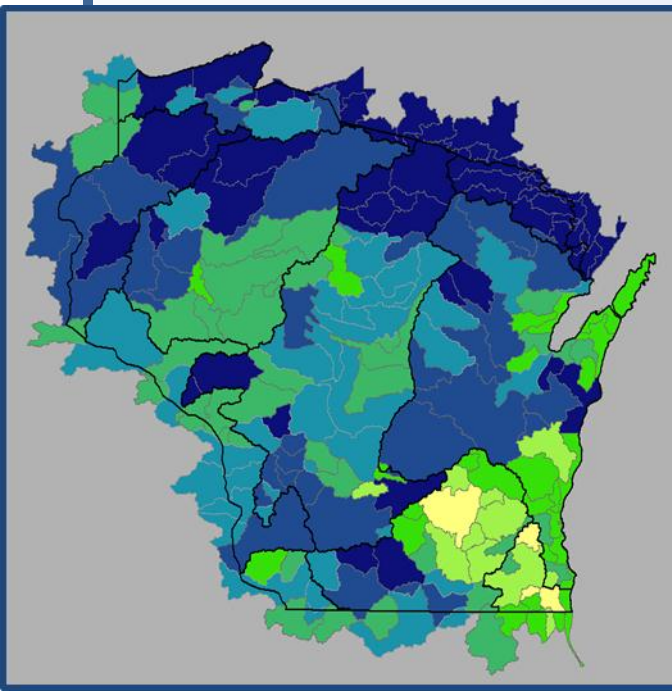
**Percent of Analysis Accumulated Total
Interflow Accounted for in Simulated Event
Runoff (All Events)**

Stratifying Percent Analysis
Accumulated Total Interflow Runoff
That is Accounted for by Runoff Events

0 - 10% Exceedance

10 - 90% Exceedance

90 - 100% Exceedance

< -2.5 Std. Dev.

-2.5 - -1.5 Std. Dev.

-1.5 - -0.50 Std. Dev.

-0.50 - 0.50 Std. Dev.

0.50 - 1.5 Std. Dev.
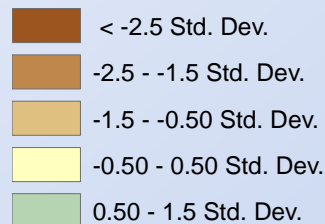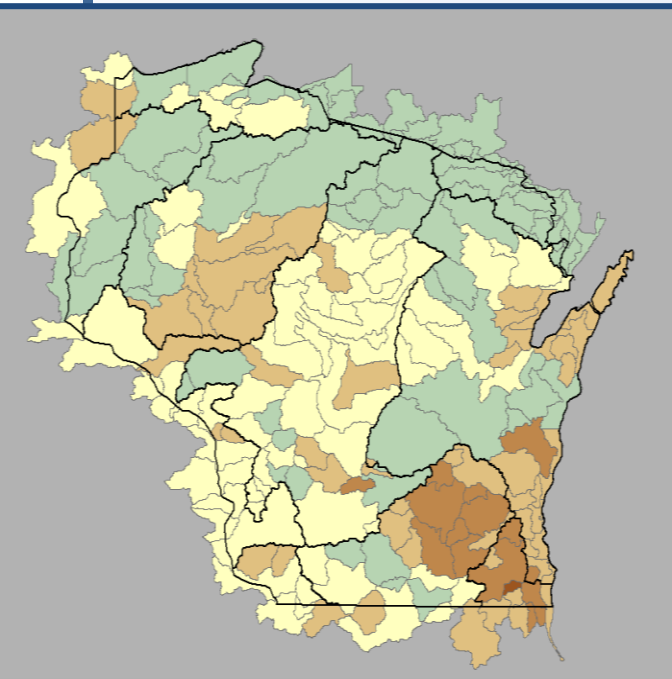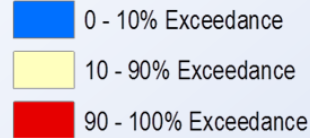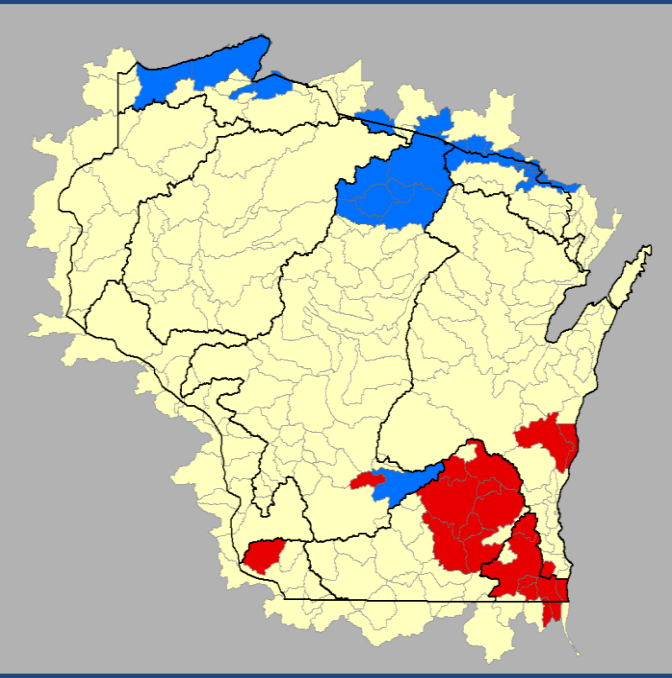
Top 10%		Bottom 10%	
COMW3	100%	NMSW3	32.7%
FLOW3	100%	RUSI2	33.5%
FLRW3	100%	WKEW3	34.3%
KFDM4	100%	MILW3	37.9%
KNGW3	100%	BEAW3	42.1%
LTKW3	100%	JFFW3	44.6%
MRNM4	100%	RAYW3	45.0%
RHIW3	100%	OMCI2	45.3%
RRVW3	100%	BABW3	46.7%
TKDW3	100%	HUSW3	47.3%
TWFM4	100%	FATW3	48.5%
WI13C	100%	WATW3	49.2%
WI14C	100%	SEBW3	49.3%
WI15C	100%	BRGW3	49.6%
WILW3	100%	INFW3	49.8%
CSPM4	99.9%	GUNI2	50.1%
PAUM4	99.8%	WMTW3	50.7%
PDSW3	99.5%	HCNW3	50.9%
BGQW3	99.4%	BTNW3	51.4%
NIAW3	99.3%	WI05C	52.3%
VLCM4	99.2%	WI01C	52.3%

Percent Analysis Accumulated Interflow Accounted for by C2 and C3 Runoff Events

C2

- 0.3 - 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%

C3

- 29 - 40%
- 40 - 50%
- 50 - 60%
- 60 - 70%
- 70 - 80%
- 80 - 90%
- 90 - 100%

C2

- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

C3

- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

C2

- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

C3

- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 1.8 Std. Dev.
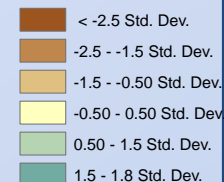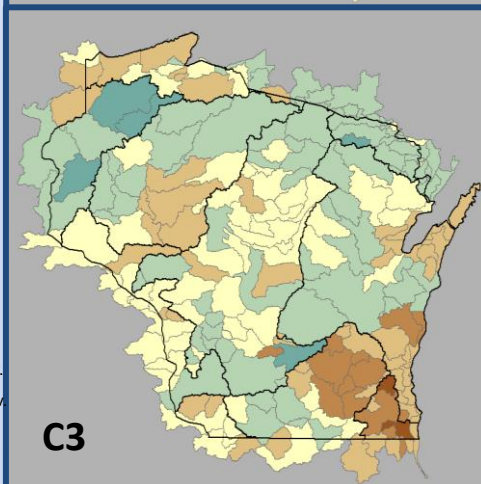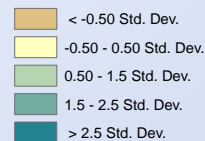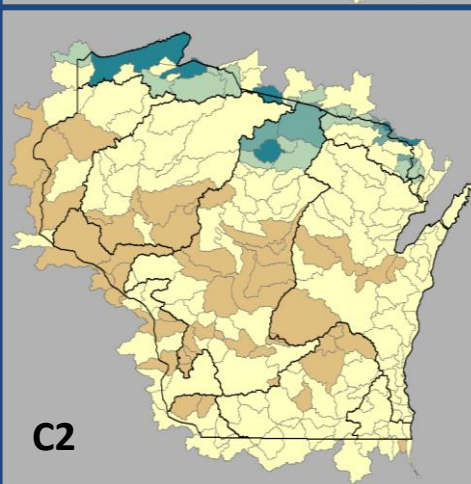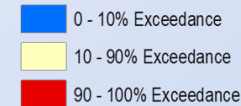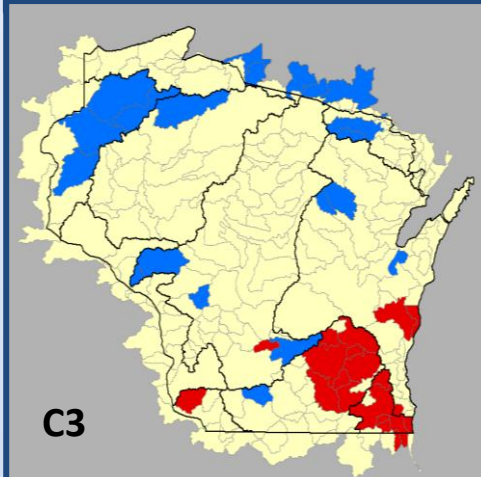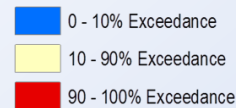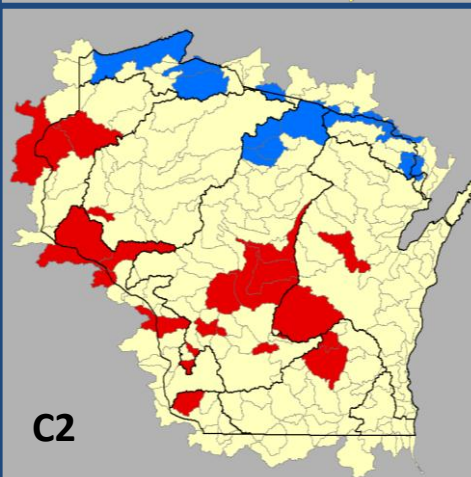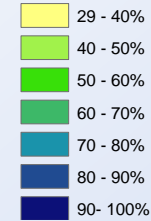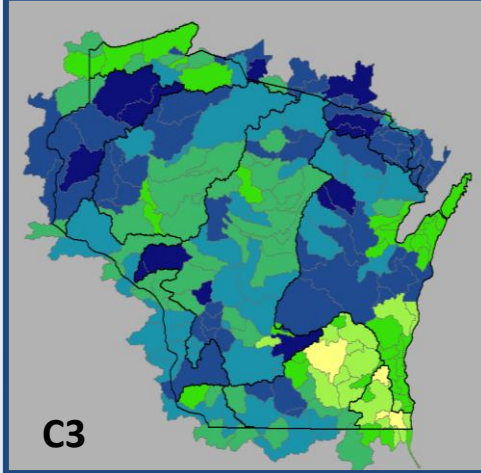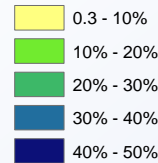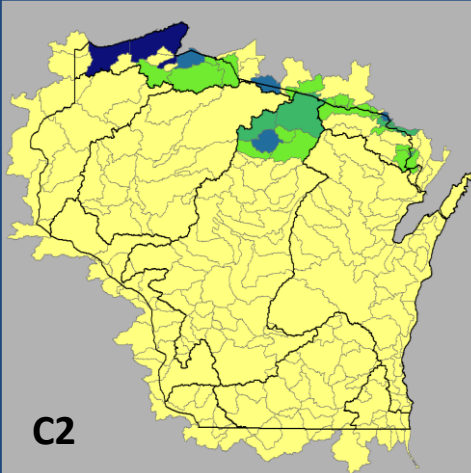
Event Runoff Summary

➢ **Event Runoff is dominated by the High Risk (C3) category events**

  ➢ *All basins accumulated runoff :: C3 = 92k mm, C2 = 4k mm*

  ➢ *Median Basin Event Runoff for C3 = 358 mm   C2 = 15 mm*

  ➢ *In general 95% of a basin Event Runoff is in C3*

  ➢ *Thresholds seem to be working :: not assigning High Risk to small volume events*

➢ **Basins with highest Event Runoff totals are in central Wisconsin**

➢ **Far northern basins again have lowest Event Runoff totals**

  ➢ *Also have the highest proportion of Event Runoff that is C2*

➢ **In terms of how much of Total Interflow Runoff for a basin was accounted for by Event Runoff:**

  ➢ *Event Runoff in far northern basins used very high percentage of total Interflow*

  ➢ *Event Runoff in southeastern basins used between 30-50% of total interflow*

Data Analysis Overview

1. **The following model parameters were analyzed:**
   - *Forecast Precipitation*   *(FMAP)*
   - *Rain+Melt*   *(RAIM)*
   - *SAC-SMA Interflow Runoff*   *(INTRO)*
   - *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**
   - ***Review Raw Simulated Events***
     - **Number of events , Amount of runoff, and Total Time per Risk Category**

   - *Review in Boolean Perspective*
     - **Does period in question have at least one event = 1, otherwise = 0**

   - *Review in Warning Day Perspective*
     - **Equivalent to RRAF map hosted by WI DATCP webpage**

   - *Review in Runoff Type Perspective*
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

Analysis Accumulated Percent of Time in Each Category

Percent Max Possible Time in Each Category for All Basins

	C1	C2	C3	C2 or C3
Median ::	91.6%	1.7%	6.6%	8.4%
Max ::	99.9%	7.1%	9.6%	11.5%
Min ::	88.5%	0.1%	0.01%	0.1%

Number of basins

Percent C2
Percent C3
Percent C1

Note : Scale Not Linear

Percent of Time in Category
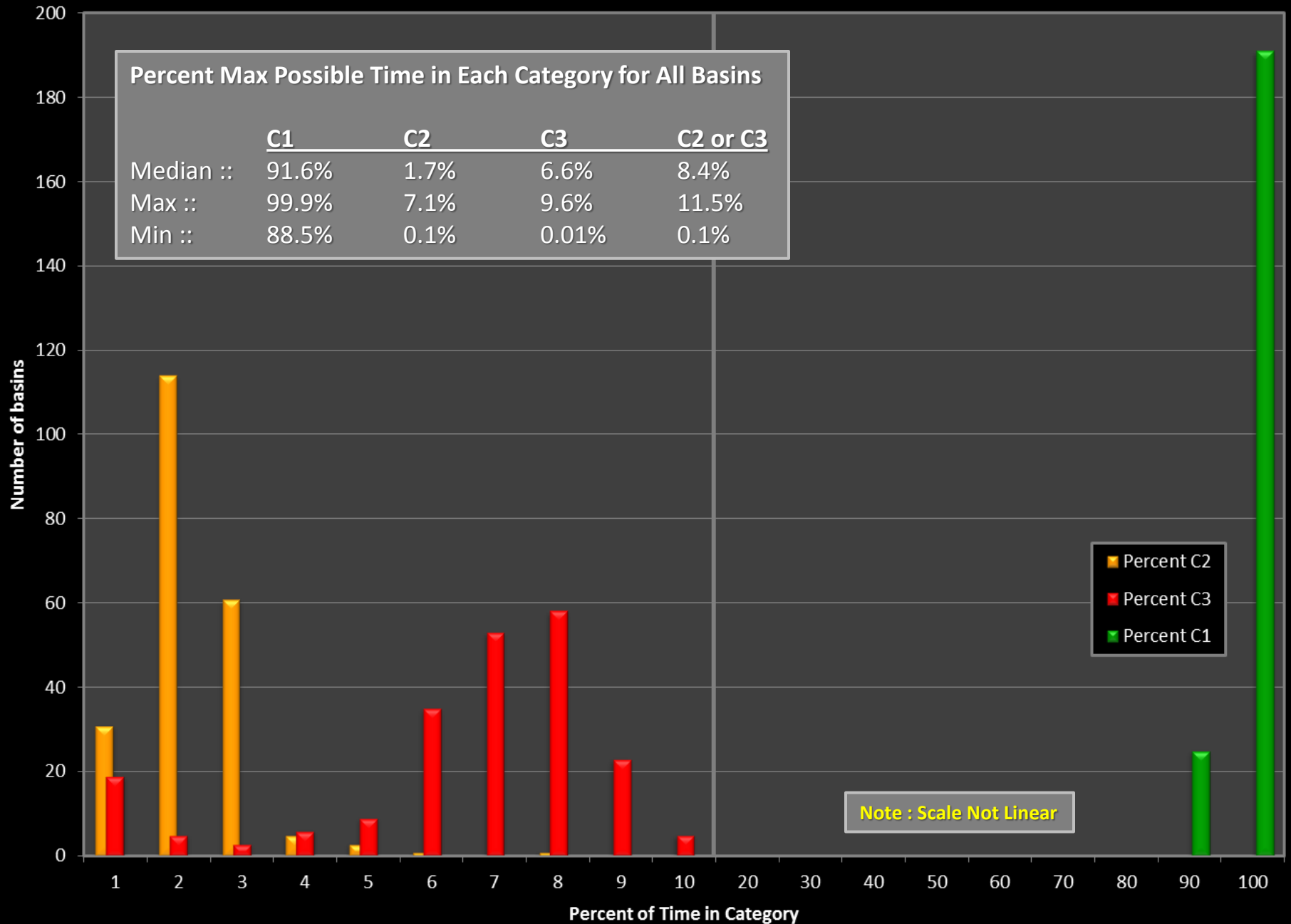
Percent of Analysis Accumulated Time Basins Are In Each Category
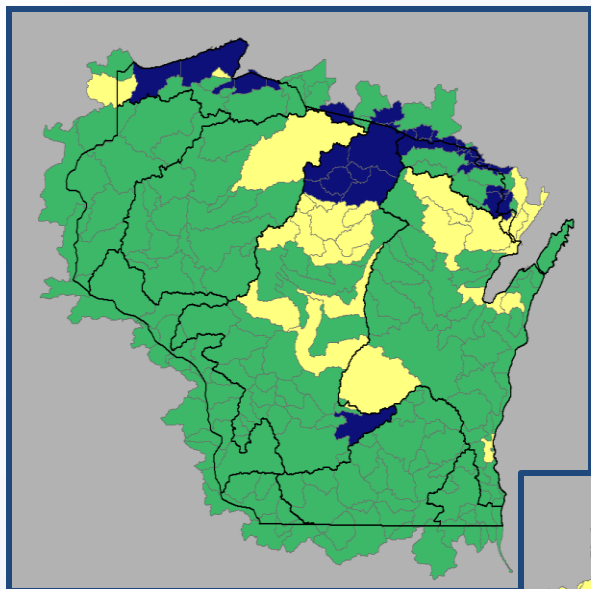
C1 – No Events

Percent Time in C1
- 88.5 - 90%
- 90 - 95%
- 95 - 100%
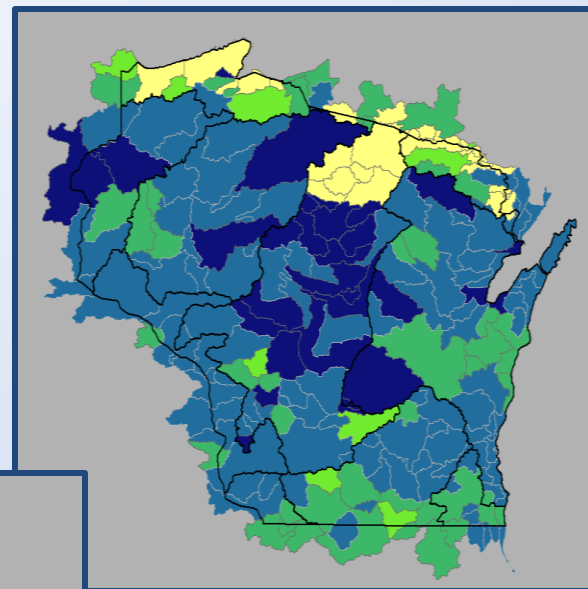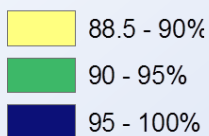
C2 – Below Threshold

C3 – Above Threshold

Percent Time in C2 or C3
- 0.01 - 2%
- 2 - 4%
- 4 - 6%
- 6 - 8%
- 8 - 10%

National Weather Service

Protecting Lives and Property
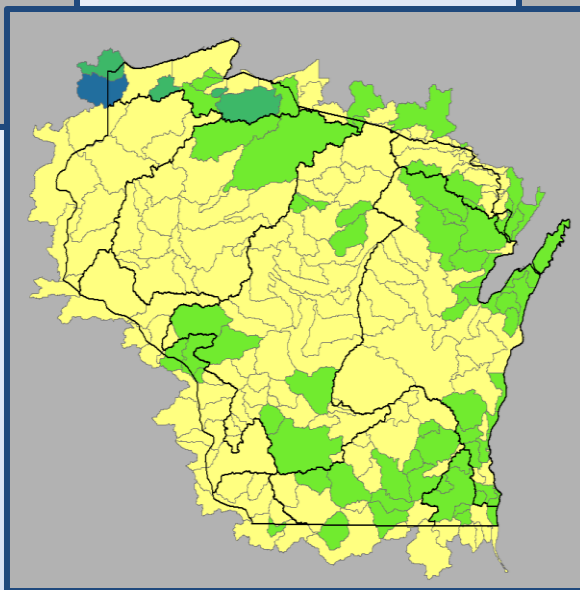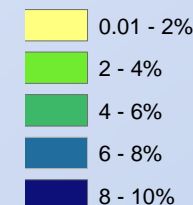
Percent Analysis Accumulated Total Time that was Category 1
(No Runoff Events)

Legend (top map):
- 0 - 10% Exceedance (blue)
- 10 - 90% Exceedance (yellow)
- 90 - 100% Exceedance (red)

Legend (bottom map):
- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.
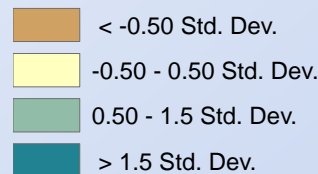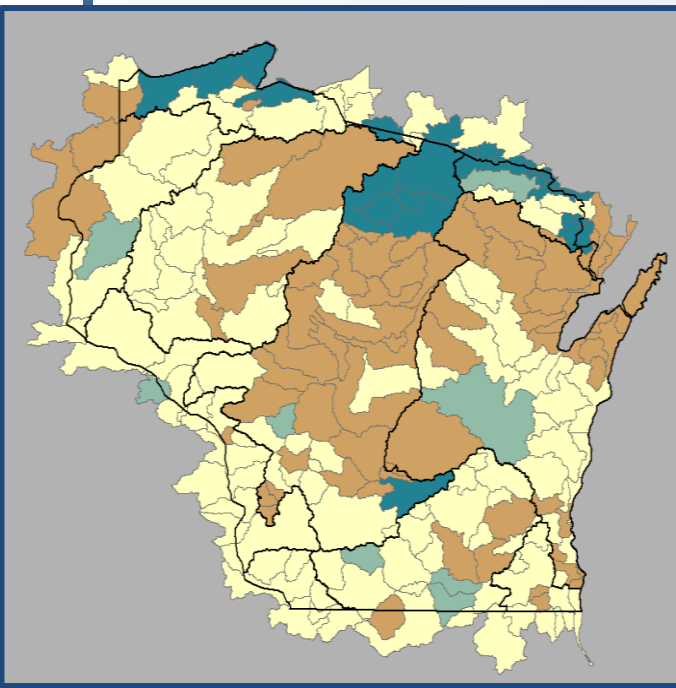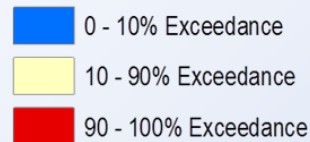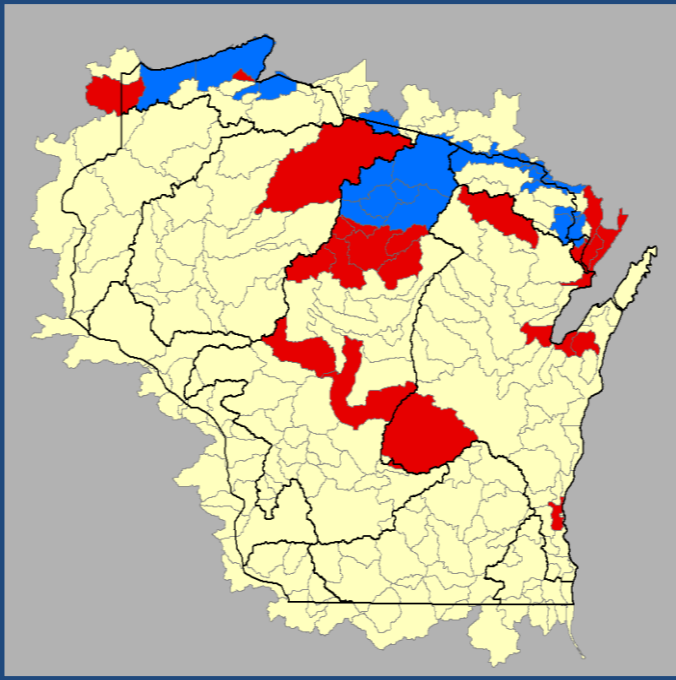
Top 10%		Bottom 10%	
WI15C	99.9%	WTLW3	88.5%
WI13C	99.8%	SOSW3	88.7%
WI14C	99.8%	HATW3	88.8%
MRNM4	99.8%	TRIW3	88.9%
TWFM4	99.2%	RRLW3	88.9%
RRVW3	99.1%	WUUW3	88.9%
LTKW3	99.0%	SPDW3	88.9%
VLCM4	99.0%	WI11C	89.3%
BANM4	99.0%	OWNW3	89.3%
FLOW3	99.0%	CRIW3	89.4%
CLKW3	98.9%	BERW3	89.4%
NIAW3	98.9%	BGFW3	89.5%
KFDM4	98.8%	WI09C	89.6%
COMW3	98.8%	MRLW3	89.6%
KOSM4	98.7%	MCAW3	89.7%
FLRW3	98.5%	RIBW3	89.7%
BGQW3	98.5%	CROW3	89.8%
KNGW3	98.4%	MI33C	89.8%
WILW3	98.3%	KEWW3	89.9%
RHIW3	98.1%	MEEW3	89.9%
TKDW3	97.9%	SCUW3	89.9%

Percent Analysis Accumulated Total Time that was Category 2
(Runoff Event < Threshold)
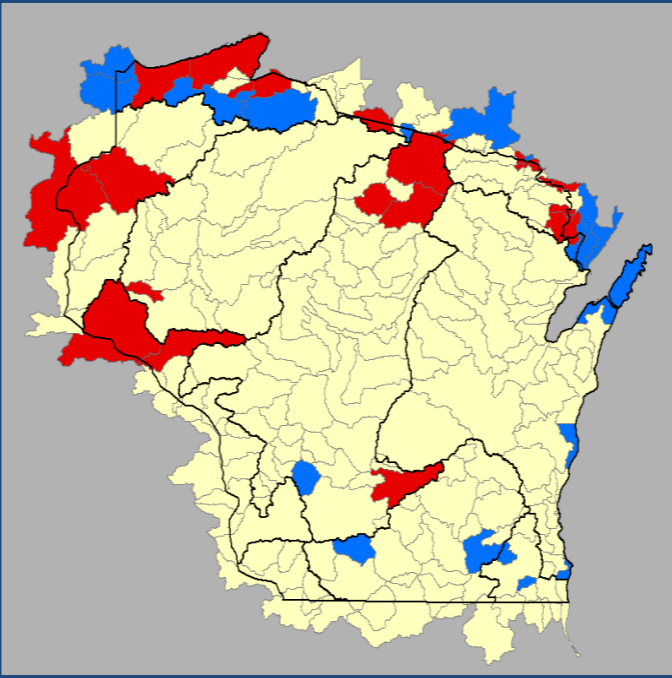
- 🟦 0 - 10% Exceedance
- 🟨 10 - 90% Exceedance
- 🟥 90 - 100% Exceedance
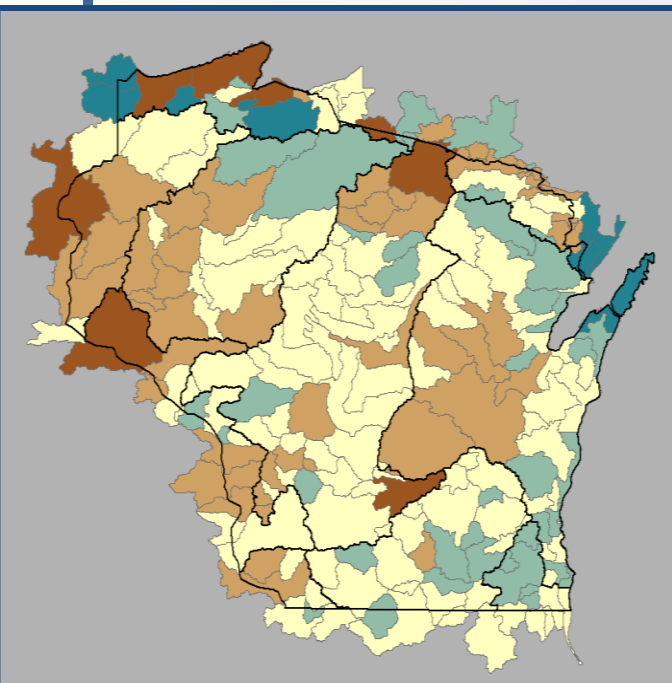
- 🟫 < -1.5 Std. Dev.
- 🟫 -1.5 - -0.50 Std. Dev.
- 🟨 -0.50 - 0.50 Std. Dev.
- 🟩 0.50 - 1.5 Std. Dev.
- 🟦 > 1.5 Std. Dev.

Top 10%		Bottom 10%	
SOSW3	7.1%	WI15C	0.1%
ODAW3	5.7%	WI13C	0.1%
WHRW3	5.0%	WI14C	0.1%
SLSW3	4.4%	MRNM4	0.1%
BRSW3	4.3%	WABM5	0.5%
GRRW3	3.6%	SCFW3	0.5%
MI33C	3.6%	PDSW3	0.5%
MCAW3	3.3%	LTKW3	0.5%
WI08C	3.1%	RRVW3	0.5%
SCUW3	3.1%	CLKW3	0.5%
MASW3	3.0%	BANM4	0.6%
BCHW3	2.9%	TWFM4	0.6%
ORCM4	2.9%	MENW3	0.6%
WI05C	2.7%	GTBW3	0.6%
MUKW3	2.6%	FLOW3	0.6%
WI02C	2.6%	VLCM4	0.6%
MFSM4	2.6%	ALMW3	0.6%
RICW3	2.5%	KOSM4	0.6%
CRYM4	2.5%	COMW3	0.6%
FATW3	2.5%	NIAW3	0.7%
NMSW3	2.5%	KNGW3	0.7%

Percent Analysis Accumulated Total Time that was Category 3
(Runoff Event > Threshold)

- 🟦 0 - 10% Exceedance
- 🟨 10 - 90% Exceedance
- 🟥 90 - 100% Exceedance

- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 1.6 Std. Dev.
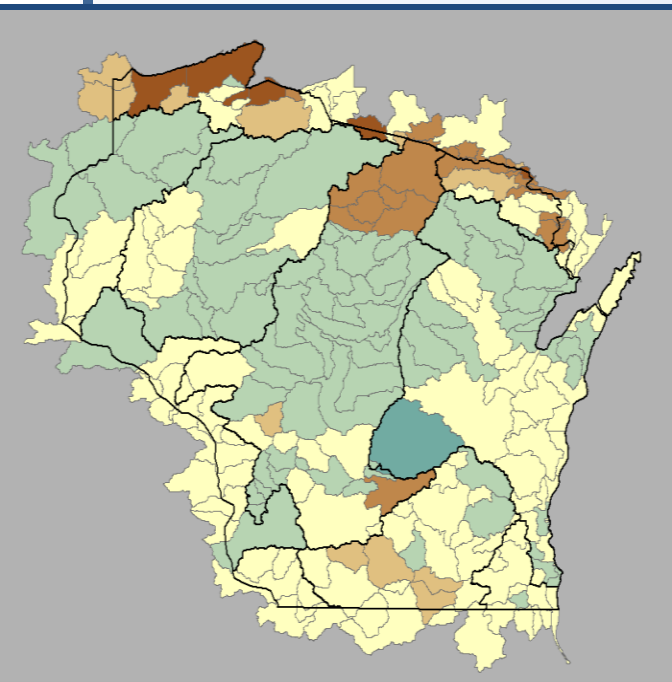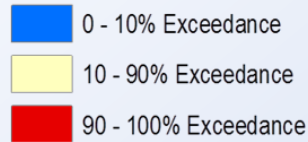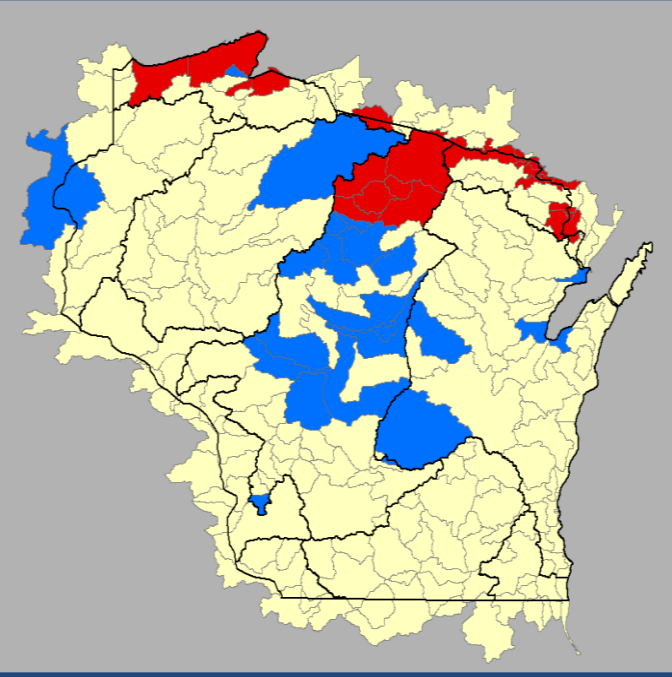
Top 10%		Bottom 10%	
BERW3	9.6%	WI15C	0.01%
HATW3	9.2%	WI14C	0.05%
RRLW3	9.2%	WI13C	0.06%
WTLW3	9.2%	MRNM4	0.08%
TRIW3	9.0%	TWFM4	0.3%
OWNW3	8.9%	RRVW3	0.4%
SCFW3	8.8%	VLCM4	0.4%
WI11C	8.8%	NIAW3	0.5%
WIRW3	8.7%	KFDM4	0.5%
SPDW3	8.7%	FLOW3	0.5%
WUUW3	8.6%	LTKW3	0.5%
NLSW3	8.5%	BANM4	0.5%
CROW3	8.4%	CLKW3	0.6%
RIBW3	8.4%	COMW3	0.6%
ROYW3	8.4%	BGQW3	0.7%
WI09C	8.4%	KOSM4	0.7%
DUBW3	8.3%	FLRW3	0.8%
STPW3	8.3%	WILW3	0.9%
STEW3	8.3%	KNGW3	0.9%
BRFW3	8.3%	RHIW3	1.0%
BGFW3	8.2%	TKDW3	1.1%

Analysis Accumulated Percent Time of Simulated Runoff Events in C2 or C3

Percent Time In Each Category When Runoff Events Were Simulated for All Basins

	C2	C3
Median ::	22.5%	77.5%
Max ::	88.9%	93.9%
Min ::	5.3%	11.1%
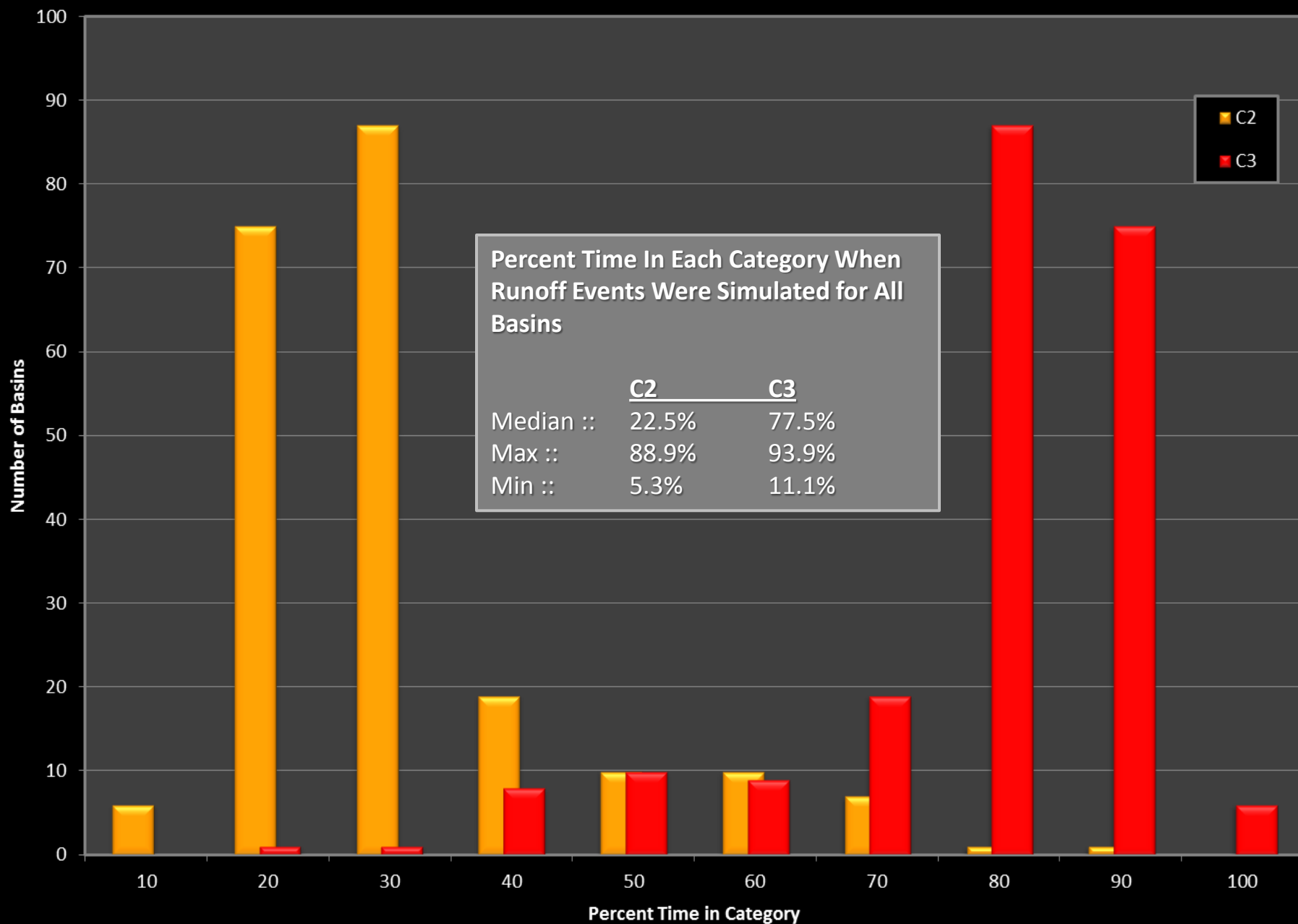
Time in Runoff Categories Summary

➢ **Basins in general were in Low Risk (C1 = No event) 91% of the time**

  ➢ *9% of the time a runoff event was simulated (Max = 11% Min = 0.1%)*

  ➢ *2% of the time the runoff event was Medium Risk (C2)*

  ➢ *7% of the time the runoff event was High Risk (C3)*

➢ **During the time that a Runoff Event is simulated ::**

  ➢ *78% of the time it is a C3 Runoff Event*

  ➢ *22% of the time it is a C2 Runoff Event*

Data Analysis Overview

1. **The following model parameters were analyzed:**

   ➢ *Forecast Precipitation*   *(FMAP)*

   ➢ *Rain+Melt*   *(RAIM)*

   ➢ *SAC-SMA Interflow Runoff*   *(INTRO)*

   ➢ *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**

   ➢ *Review Raw Simulated Events*
     - Number of events , Amount of runoff, and Total Time per Risk Category

   ➢ ***Review in Boolean Perspective***
     - **Does period in question have at least one event = 1, otherwise = 0**

   ➢ *Review in Warning Day Perspective*
     - **Equivalent to RRAF map hosted by WI DATCP webpage**

   ➢ *Review in Runoff Type Perspective*
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

National Weather Service

Protecting Lives and Property
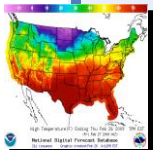
Daily Forecast Run Boolean Simulated Runoff Event Summary

➢ **Evaluate each daily forecast run for runoff event occurrence**

  ➢ *Event can occur at anytime time in forecast run*

  ➢ *Only concerned if at least one event occurs*

➢ **Boolean Approach :**

  ➢ *Each Day counted into one of two categories (1 or 0)*

  ➢ *Max possible is = daily runs = 365*

  1. *Count number of daily runs with at least one C2 event*

  2. *Count number of daily runs with at least one C3 event*

  3. *Count number of daily runs with at least one event (any Category)*

  4. *Count number of daily runs with no event simulated*

National Weather Service

Protecting Lives and Property

Daily Forecast Runs with At Least One Runoff Event

Number of Forecast Runs that have at least One Runoff Event Simulated (C2, C3, or Either)

	C2	C3	Either
Median ::	62	88	151
Max ::	109	128	218
Min ::	8	1	9

Legend:
- C2 Bool Evts
- C3 Bool Evts
- All Bool Evts

Y-axis: Number of Basins
X-axis: Daily Runs with Boolean Runoff Event
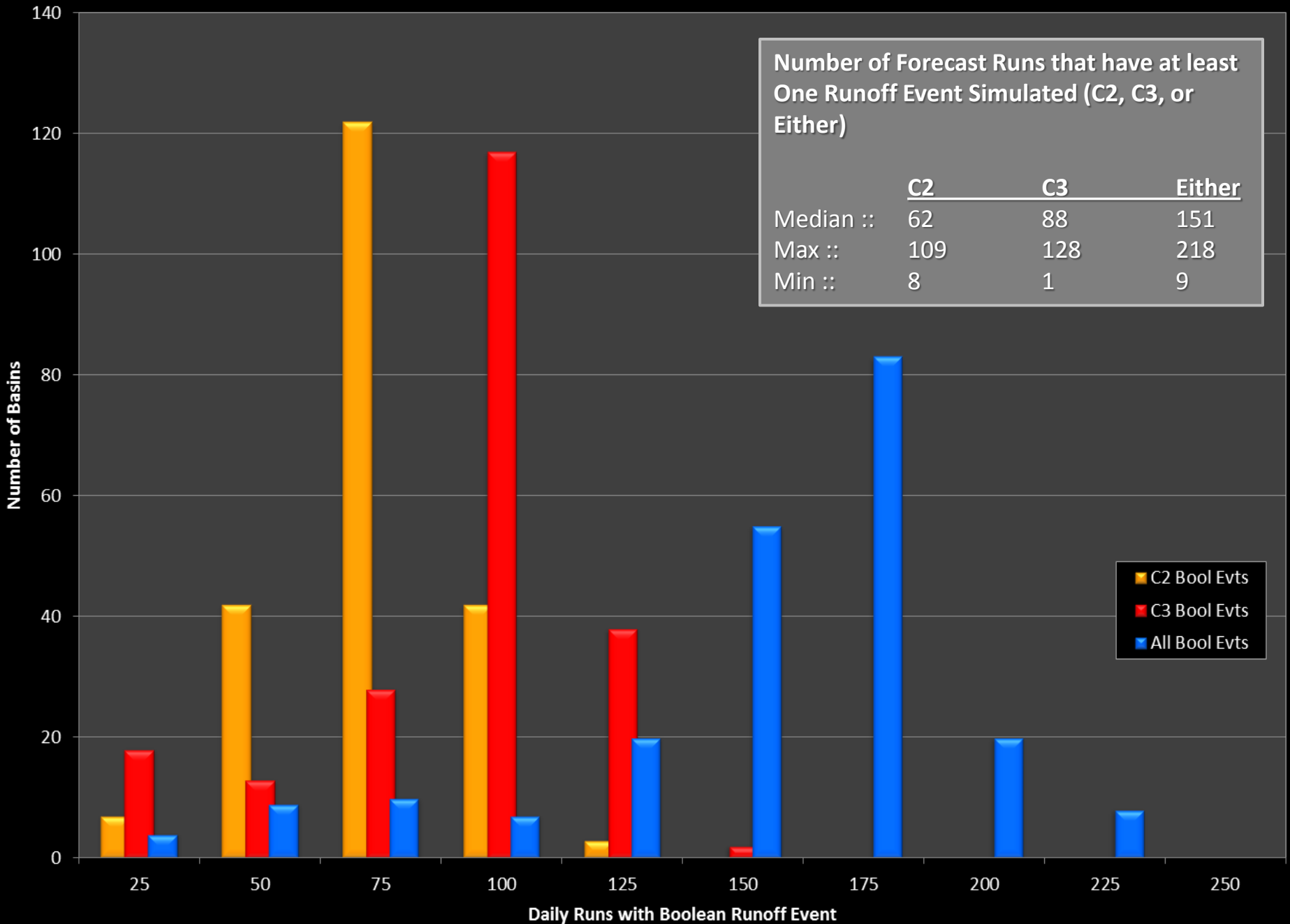
Daily Forecast Runs with At Least One Event by Category

C2

Legend:
- 1 - 25
- 26 - 50
- 51 - 75
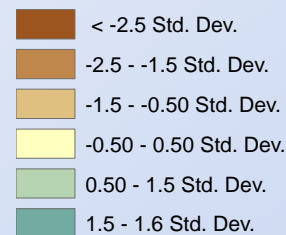- 76 - 100
- 101 - 128

C3

- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Std. Dev. legend:
- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.
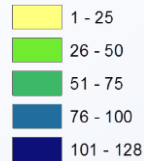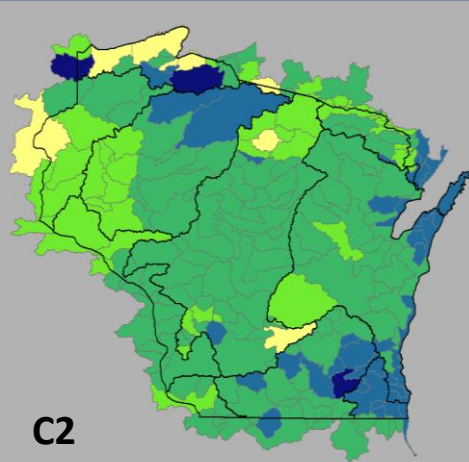
➤ **Scales are the same for both Categories**
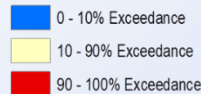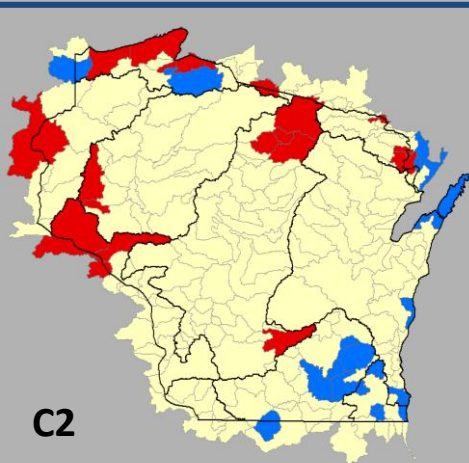
➤ **This is Boolean Runoff Event Occurrence**
  - ➤ *# of Daily runs*
  - ➤ *365 = Max possible*

➤ **At least one simulated event in a daily forecast run scores as true, otherwise false for that daily run**
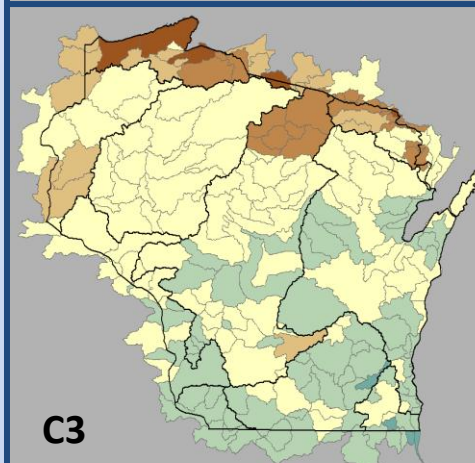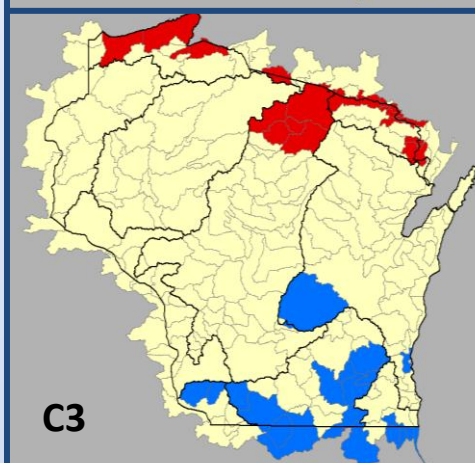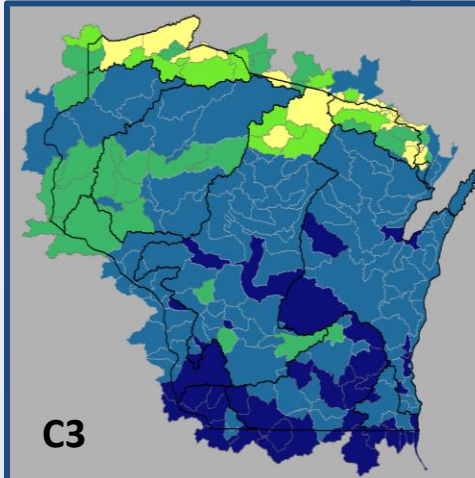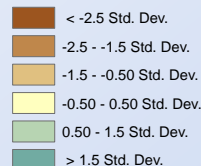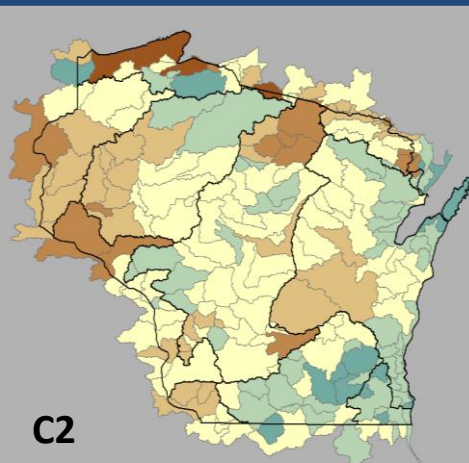
Daily Forecast Runs with Boolean C2 & C3 Simulated Runoff Event Occurrence

C2	Top 10%		Bottom 10%	
	ODAW3	109	WI15C	8
	FATW3	104	WI14C	8
	SOSW3	102	WI13C	8
	JFFW3	98	MRNM4	9
	WI08C	95	SCFW3	22
	INFW3	94	PDSW3	23
	MI33C	94	RRVW3	25
	MUKW3	94	WABM5	26
	GRRW3	92	ALMW3	26
	WI02C	92	MENW3	27
	WMTW3	91	LTKW3	27
	FEEI2	90	WI12C	28
	WATW3	90	KNGW3	29
	WKEW3	90	MSCM5	30
	MCAW3	88	CLKW3	31
	WHRW3	87	TWFM4	32
	WI05C	87	RHIW3	32
	WI01C	86	KOSM4	32
	HUSW3	85	BANM4	32
	NMSW3	85	WHEW3	33
	RACW3	85	FLOW3	33

C3	Top 10%		Bottom 10%	
	GUNI2	128	WI15C	1
	WMTW3	127	WI14C	2
	ROMW3	124	WI13C	2
	IL02C	123	MRNM4	4
	FEEI2	120	TWFM4	9
	BERW3	118	VLCM4	13
	JHNI2	118	RRVW3	13
	WATW3	116	NIAW3	14
	BTNW3	114	FLOW3	14
	JFFW3	114	KFDM4	15
	OMCI2	114	BANM4	17
	FATW3	113	WI12C	18
	MNTW3	113	LTKW3	18
	INFW3	112	COMW3	19
	MEEW3	112	CLKW3	19
	LATI2	111	BGQW3	19
	SIRI2	110	KOSM4	22
	BVDI2	109	FLRW3	23
	RVLW3	109	KNGW3	27
	CLIW3	108	WILW3	28
	DARW3	108	RHIW3	28
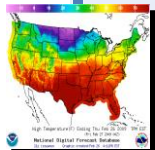
Daily Forecast Runs with Boolean Event and No Event Occurrence

Number of Forecast Runs that have at least One Runoff Event or No Event

	Event	No Event
Median ::	151	214
Max ::	218	356
Min ::	9	147

Legend:
- Event Simulated
- No Event Simulated

Y-axis: Number of Basins
X-axis: Daily Runs
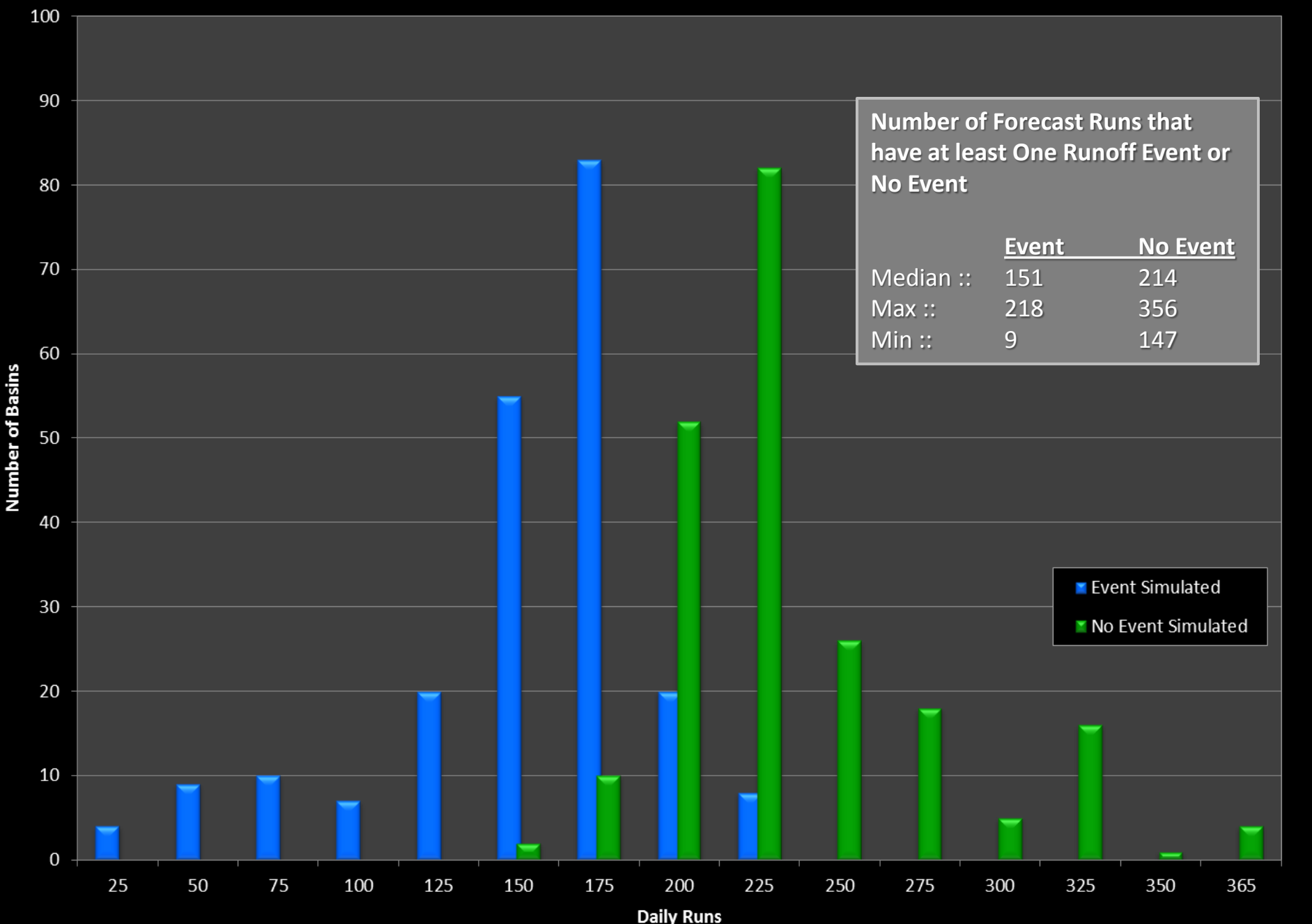
Daily Forecast Run Boolean Occurrence of Any Runoff Events

Legend (top map):
- 9 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 218

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.
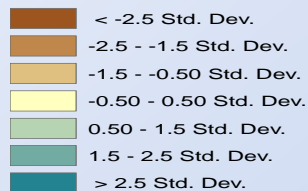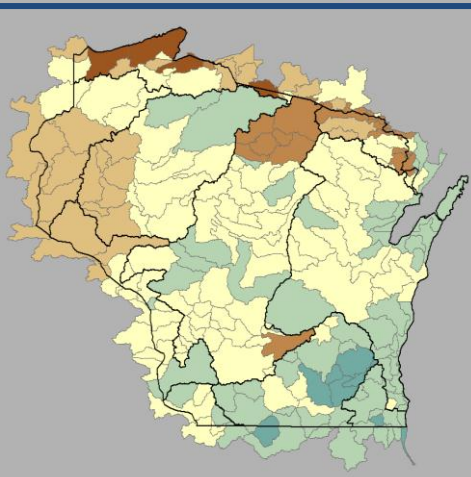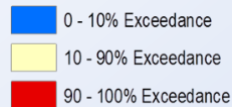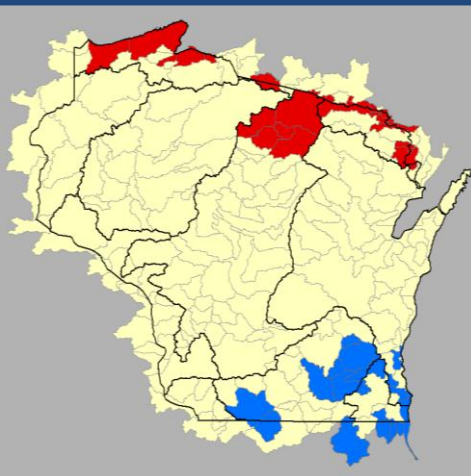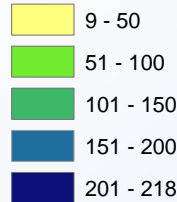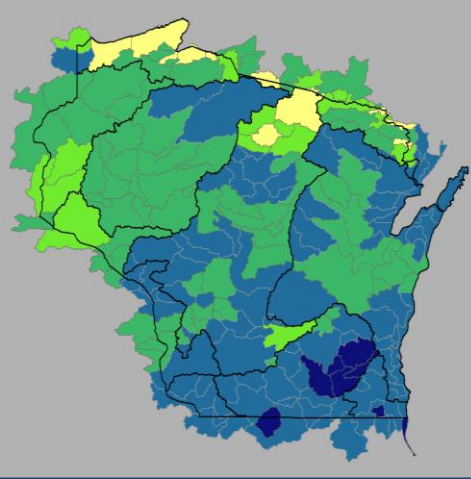
Top 10%			Bottom 10%		
WMTW3	218	59.7%	WI15C	9	2.5%
FATW3	217	59.5%	WI14C	10	2.7%
JFFW3	212	58.1%	WI13C	10	2.7%
FEEI2	210	57.5%	MRNM4	13	3.6%
IL02C	207	56.7%	RRVW3	38	10.4%
INFW3	206	56.4%	TWFM4	41	11.2%
WATW3	206	56.4%	LTKW3	45	12.3%
ROMW3	205	56.2%	WI12C	46	12.6%
MUKW3	200	54.8%	VLCM4	47	12.9%
MEEW3	193	52.9%	FLOW3	47	12.9%
WI01C	192	52.6%	NIAW3	48	13.2%
GUNI2	191	52.3%	BANM4	49	13.4%
MTNW3	188	51.5%	CLKW3	50	13.7%
JHNI2	187	51.2%	KOSM4	54	14.8%
WI02C	187	51.2%	KFDM4	54	14.8%
OMCI2	185	50.7%	COMW3	55	15.1%
WKEW3	185	50.7%	KNGW3	56	15.3%
FRKW3	182	49.9%	BGQW3	59	16.2%
BVDI2	181	49.6%	RHIW3	60	16.4%
HUSW3	181	49.6%	FLRW3	60	16.4%
RACW3	181	49.6%	WILW3	63	17.3%

Daily Forecast Run Boolean Non-Occurrence of Runoff Events

147 - 150
151 - 200
201 - 250
251 - 300
301 - 356

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -2.5 Std. Dev.
-2.5 - -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.
> 2.5 Std. Dev.
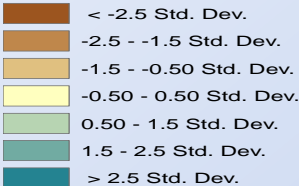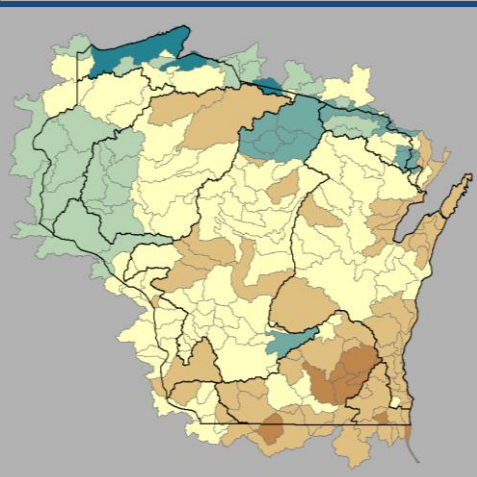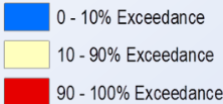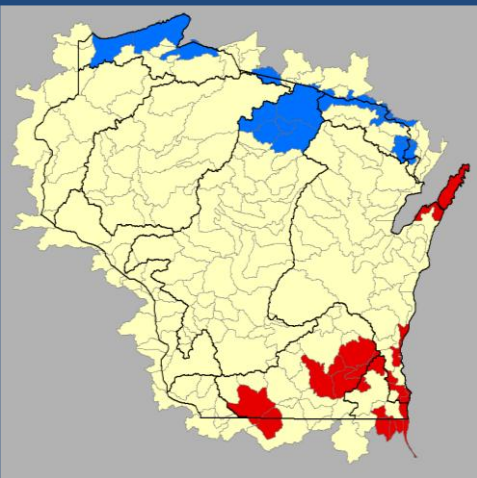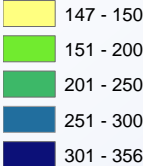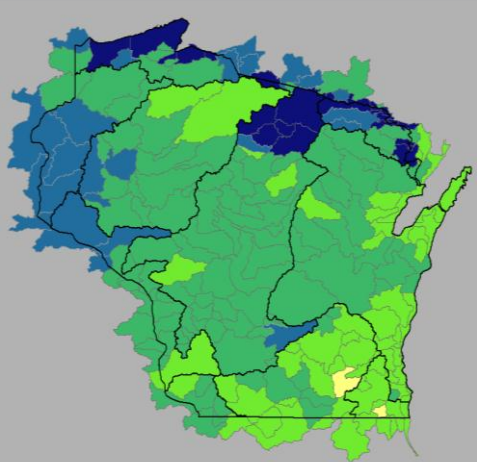
Top 10%			Bottom 10%		
WI15C	356	97.5%	WMTW3	147	40.3%
WI13C	355	97.3%	FATW3	148	40.6%
WI14C	355	97.3%	JFFW3	153	41.9%
MRNM4	352	96.4%	FEEI2	155	42.5%
RRVW3	327	89.6%	IL02C	158	43.3%
TWFM4	324	88.8%	WATW3	159	43.6%
LTKW3	320	87.7%	INFW3	159	43.6%
WI12C	319	87.4%	ROMW3	160	43.8%
VLCM4	318	87.1%	MUKW3	165	45.2%
FLOW3	318	87.1%	MEEW3	172	47.1%
NIAW3	317	86.9%	WI01C	173	48.8%
BANM4	316	86.6%	GUNI2	174	47.7%
CLKW3	315	86.3%	MTNW3	177	48.5%
KOSM4	311	85.2%	WI02C	178	48.8%
KFDM4	311	85.2%	JHNI2	178	48.8%
COMW3	310	84.9%	OMCI2	180	49.3%
KNGW3	309	84.7%	WKEW3	180	50.1%
BGQW3	306	83.8%	FRKW3	183	50.4%
RHIW3	305	83.6%	WI08C	184	50.4%
FLRW3	305	83.6%	WI04C	184	50.4%
WILW3	302	82.7%	RACW3	184	50.4%

Percent of Daily Forecast Runs with At Least One Runoff Event

Number of Basins (y-axis): 0, 20, 40, 60, 80, 100, 120, 140, 160

Percent Daily Runs (x-axis): 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Percent Forecast Runs that have At Least One Runoff Event Simulated By Category

	C2	C3
Median ::	17%	24%
Max ::	30%	35%
Min ::	2%	0.3%

Legend: C2 Bool, C3 Bool
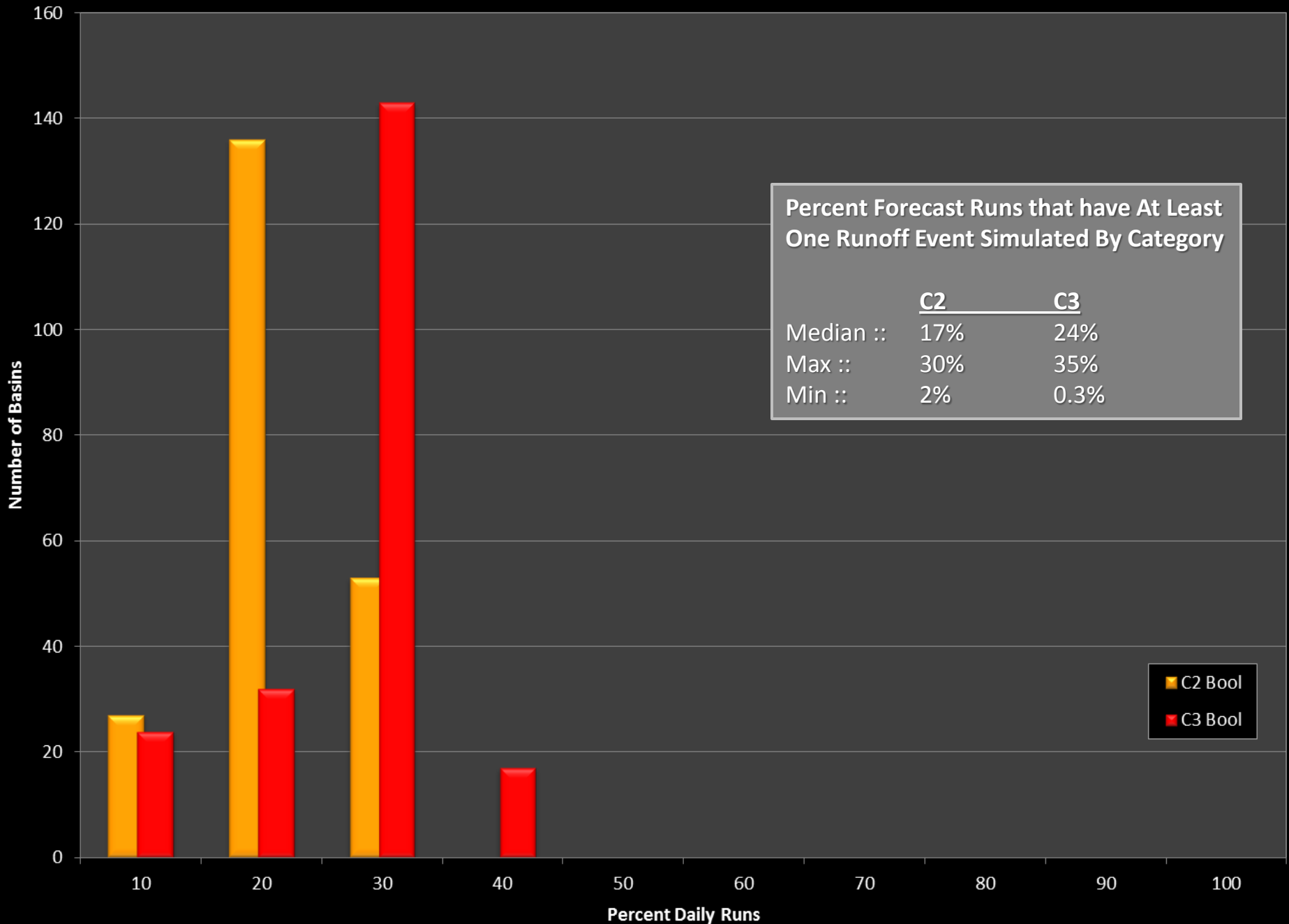
Percent Daily Forecast Runs with Boolean Occurrence of C2 & C3 Runoff Events

C2

	0 - 5%
	5 - 10%
	10 - 15%
	15 - 20%
	20 - 25%
	25 - 30%
	30 - 35%

➢ **Percent Daily Forecast Runs with at least one C2 Simulated Runoff Event**

C3

	0 - 5%
	5 - 10%
	10 - 15%
	15 - 20%
	20 - 25%
	25 - 30%
	30 - 35%
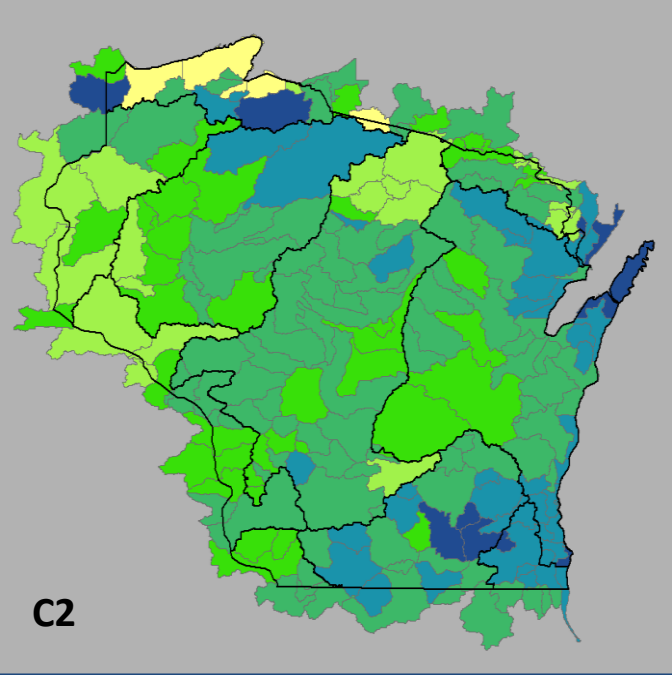
➢ **Percent Daily Forecast Runs with at least one C3 Simulated Runoff Event**
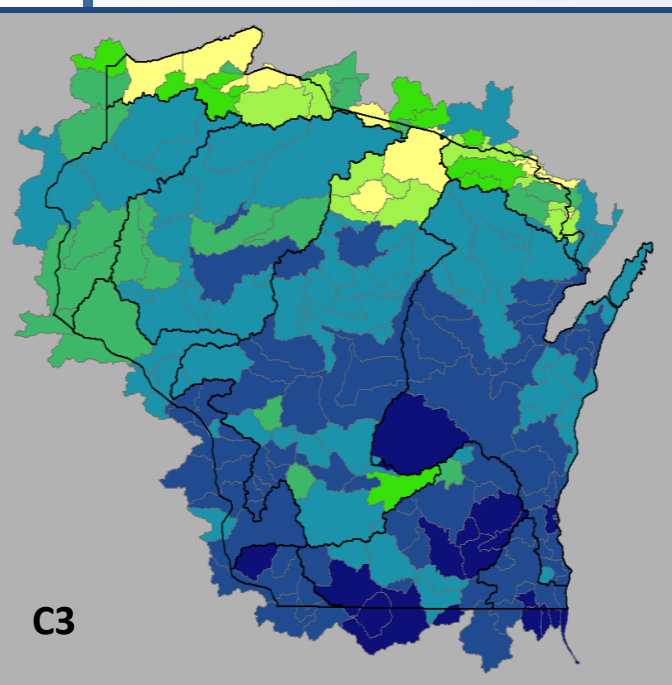
Percent Daily Forecast Runs Runoff Event Occurrence & Non-Occurrence

	-
	2 - 10%
	10 - 20%
	20 - 30%
	30 - 40%
	40 - 50%
	50 - 60%

➤ **Percent Daily Forecast Runs with Any Simulated Runoff Event**

	40 - 50%
	50 - 60%
	60 - 70%
	70 - 80%
	80 - 90%
	90 - 100%
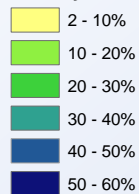
➤ **Percent Daily Forecast Runs with No Simulated Runoff Event**
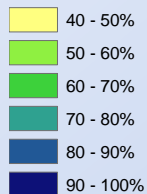
Boolean Runoff Event Summary

➢ **Values are in terms of number of runs = 365 possible**

➢ **Median number of runs with Boolean Runoff Events ::**
  - ➢ *Any = 151 (Max = 218, Min = 9)*
  - ➢ *C2 = 62*
  - ➢ *C3 = 88*

➢ **Median Runs with No Event = 214**
  - ➢ *Max = 356, Min = 147*

➢ **Median Percent of daily runs that had ::**
  - ➢ *No Event = 59%*
  - ➢ *Any Event = 41%, C2 = 17%, C3 = 24%*

➢ **Basins with highest number of events again in the south, lowest number again in the far north**

Data Analysis Overview

1. **The following model parameters were analyzed:**

   - *Forecast Precipitation*   *(FMAP)*
   - *Rain+Melt*   *(RAIM)*
   - *SAC-SMA Interflow Runoff*   *(INTRO)*
   - *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**

   - *Review Raw Simulated Events*
     - Number of events , Amount of runoff, and Total Time per Risk Category

   - *Review in Boolean Perspective*
     - Does period in question have at least one event = 1, otherwise = 0

   - ***Review in Warning Day Perspective***
     - **Equivalent to RRAF map hosted by WI DATCP webpage**

   - *Review in Runoff Type Perspective*
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

National Weather Service

Protecting Lives and Property

Recall Definition of a Warning Day

➢ **A basin is coded medium or high risk if a simulated event occurs at any time in that Warning Day.**

  ➢ *High risk overrules medium risk*

  ➢ *Multiple events could occur in a warning day, however <u>only one event is required</u> to make the entire 3 day period coded for that risk*

➢ **Example of Warning Day concept**

➢ **This is equivalent to what Public sees on the Wisconsin DATCP website ::** http://www.manureadvisorysystem.wi.gov/app/events/runoff_forecast
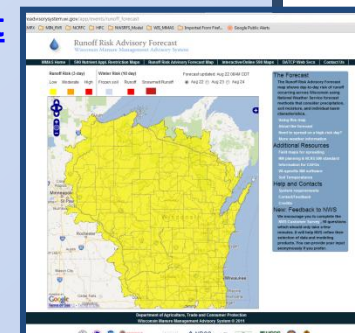
Boolean Occurrence of C2 Warning Day Runoff Events for All Daily Runs

Number of Forecast Runs that have At Least One C2 Runoff Event Simulated for a Given Warning Day

	WD1	WD2	WD3	WDX
Median ::	28	55	45	24
Max ::	54	100	83	51
Min ::	5	6	4	0
Sum ::	6,112	11,532	9,619	4,912

Legend:
- WD1 C2 Bool Events
- WD2 C2 Bool Events
- WD3 C2 Bool Events
- WDX C2 Bool Events

Y-axis: Number of Basins

X-axis: Daily runs with Boolean Warning Day Event Present

Warning Day 1 Boolean Occurrence of C2 Runoff Events

Legend (top map):
- 5 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.

Top 10%			Bottom 10%		
JFFW3	54	14.8%	MRNM4	5	1.4%
FATW3	52	14.3%	WI15C	6	1.6%
INFW3	51	14.0%	WI14C	6	1.6%
ODAW3	50	13.7%	WI13C	6	1.6%
WATW3	50	13.7%	MENW3	9	2.5%
GRRW3	49	13.4%	WHEW3	11	3.0%
MI33C	49	13.4%	WABM5	11	3.0%
MUKW3	49	13.4%	KNGW3	11	3.0%
HUSW3	48	13.2%	WI12C	12	3.3%
WI08C	48	13.2%	RRVW3	12	3.3%
WMTW3	48	13.2%	CLKW3	12	3.3%
WKEW3	47	12.9%	ALMW3	12	3.3%
MCAW3	45	12.3%	STEW3	13	3.6%
SCUW3	45	12.3%	SNDW3	13	3.6%
WI01C	45	12.3%	SCFW3	13	3.6%
FEEI2	44	12.1%	RHIW3	13	3.6%
RICW3	44	12.1%	PAUM4	13	3.6%
WI02C	44	12.1%	LTKW3	13	3.6%
WUUW3	44	12.1%	MSCM5	14	3.8%
WI05C	43	11.8%	HILW3	14	3.8%
IL02C	42	11.5%	FLRW3	14	3.8%

Warning Day 2 Boolean Occurrence of C2 Runoff Events

| 6 - 20 |
| 21 - 40 |
| 41 - 60 |
| 61 - 80 |
| 81 - 100 |

| 0 - 10% Exceedance |
| 10 - 90% Exceedance |
| 90 - 100% Exceedance |

| < -2.5 Std. Dev. |
| -2.5 - -1.5 Std. Dev. |
| -1.5 - -0.50 Std. Dev. |
| -0.50 - 0.50 Std. Dev. |
| 0.50 - 1.5 Std. Dev. |
| > 1.5 Std. Dev. |
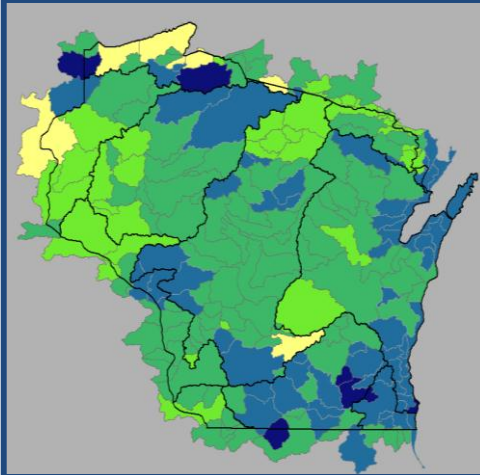
Top 10%			Bottom 10%		
ODAW3	100	27.4%	WI14C	6	1.6%
SOSW3	94	25.8%	WI13C	6	1.6%
FATW3	92	25.2%	WI15C	7	1.9%
JFFW3	83	22.7%	MRNM4	9	2.5%
MUKW3	82	22.5%	SCFW3	18	4.9%
WI02C	82	22.5%	PDSW3	18	4.9%
FEEI2	81	22.2%	RRVW3	22	6.0%
INFW3	80	21.9%	LTKW3	23	6.3%
WI08C	80	21.9%	WI12C	24	6.6%
GRRW3	79	21.6%	MENW3	24	6.6%
NMSW3	78	21.4%	KNGW3	24	6.6%
WI05C	78	21.4%	ALMW3	24	6.6%
MI33C	77	21.1%	WABM5	25	6.9%
WKEW3	77	21.1%	KOSM4	27	7.4%
RACW3	76	20.8%	RHIW3	28	7.7%
WATW3	76	20.8%	MSCM5	28	7.7%
WHRW3	76	20.8%	GTBW3	29	8.0%
WMTW3	76	20.8%	TWFM4	30	8.2%
WI01C	75	20.6%	PREW3	30	8.2%
SPDW3	74	20.3%	CLKW3	30	8.2%
BCHW3	73	20.0%	BANM4	30	8.2%

Warning Day 3 Boolean Occurrence of C2 Runoff Events

Top 10%			Bottom 10%		
ODAW3	83	22.7%	WI14C	4	1.1%
SOSW3	81	22.2%	WI13C	4	1.1%
FATW3	71	19.5%	WI15C	5	1.4%
WI02C	70	19.2%	MRNM4	5	1.4%
BCHW3	67	18.4%	SCFW3	12	3.3%
WI08C	67	18.4%	PDSW3	12	3.3%
FEEI2	65	17.8%	WABM5	18	4.9%
GRRW3	65	17.8%	RRVW3	19	5.2%
WKEW3	65	17.8%	LTKW3	19	5.2%
JFFW3	64	17.5%	GTBW3	19	5.2%
SPDW3	64	17.5%	WI12C	20	5.5%
MUKW3	63	17.3%	KOSM4	20	5.5%
RACW3	63	17.3%	ALMW3	20	5.5%
WATW3	63	17.3%	KNGW3	21	5.8%
INFW3	62	17.0%	MENW3	22	6.0%
NMSW3	62	17.0%	FLOW3	23	6.3%
WI05C	62	17.0%	COMW3	23	6.3%
MCAW3	61	16.7%	TWFM4	24	6.6%
WHRW3	61	16.7%	MSCM5	24	6.6%
MEEW3	60	16.4%	BANM4	24	6.6%
MI33C	60	16.4%	RHIW3	25	6.9%

Warning Day X Boolean Occurrence of C2 Runoff Events

Exceedance legend	
0 - 10	
11 - 20	
21 - 30	
31 - 40	
41 - 51	

0 - 10% Exceedance	
10 - 90% Exceedance	
90 - 100% Exceedance	

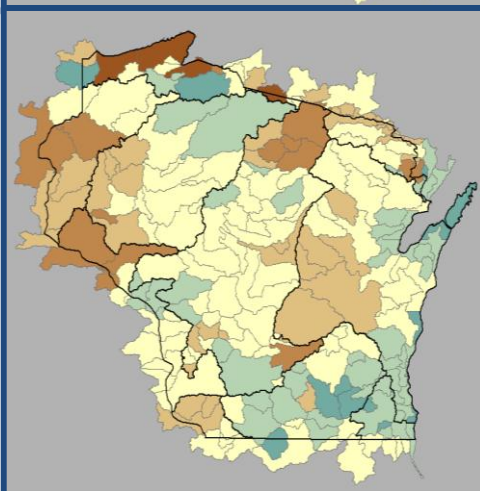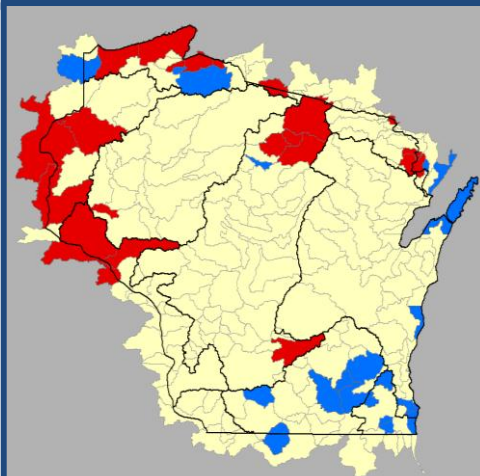|	
< -1.5 Std. Dev.	
-1.5 - -0.50 Std. Dev.	
-0.50 - 0.50 Std. Dev.	
0.50 - 1.5 Std. Dev.	
1.5 - 2.5 Std. Dev.	
> 2.5 Std. Dev.	

Top 10%			Bottom 10%		
ODAW3	83	22.7%	WI14C	4	1.1%
SOSW3	81	22.2%	WI13C	4	1.1%
FATW3	71	19.5%	WI15C	5	1.4%
WI02C	70	19.2%	MRNM4	5	1.4%
BCHW3	67	18.4%	SCFW3	12	3.3%
WI08C	67	18.4%	PDSW3	12	3.3%
FEEI2	65	17.8%	WABM5	18	4.9%
GRRW3	65	17.8%	RRVW3	19	5.2%
WKEW3	65	17.8%	LTKW3	19	5.2%
JFFW3	64	17.5%	GTBW3	19	5.2%
SPDW3	64	17.5%	WI12C	20	5.5%
MUKW3	63	17.3%	KOSM4	20	5.5%
RACW3	63	17.3%	ALMW3	20	5.5%
WATW3	63	17.3%	KNGW3	21	5.8%
INFW3	62	17.0%	MENW3	22	6.0%
NMSW3	62	17.0%	FLOW3	23	6.3%
WI05C	62	17.0%	COMW3	23	6.3%
MCAW3	61	16.7%	TWFM4	24	6.6%
WHRW3	61	16.7%	MSCM5	24	6.6%
MEEW3	60	16.4%	BANM4	24	6.6%
MI33C	60	16.4%	RHIW3	25	6.9%

Percent Daily Forecast Runs with C2 Runoff Event Boolean Occurrence for each Warning Day

Percent Forecast Runs that have At Least One C2 Runoff Event Simulated for a Given Warning Day

	WD1	WD2	WD3	WDX
Median ::	7.7%	15.1%	12.3%	6.6%
Max ::	14.8%	27.4%	22.7%	14.0%
Min ::	1.4%	1.6%	1.1%	0%

Legend:
- Percent WD1 C2
- Percent WD2 C2
- Percent WD3 C2
- Percent WDX C2

Y-axis: Number of Basins

X-axis: Percent of Daily Runs with Warning Day Event Occurrence

Percent Daily Forecast Runs with C2 Runoff Event Boolean Occurrence for each Warning Day
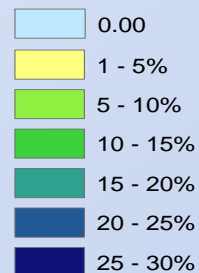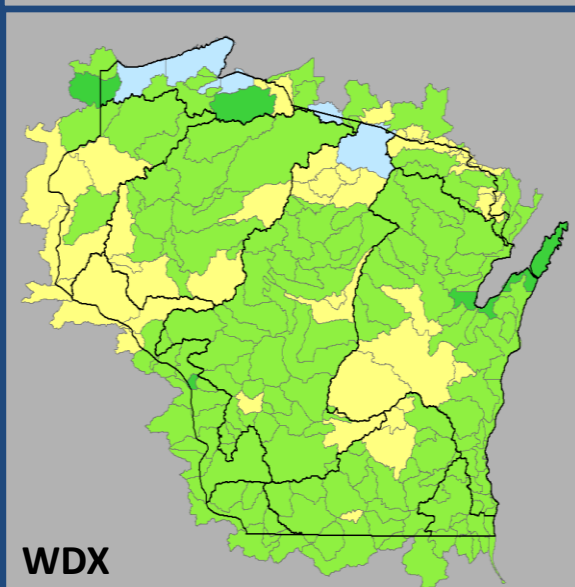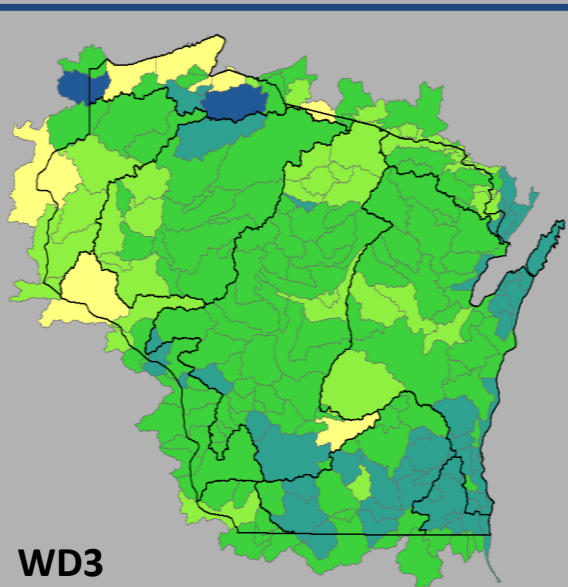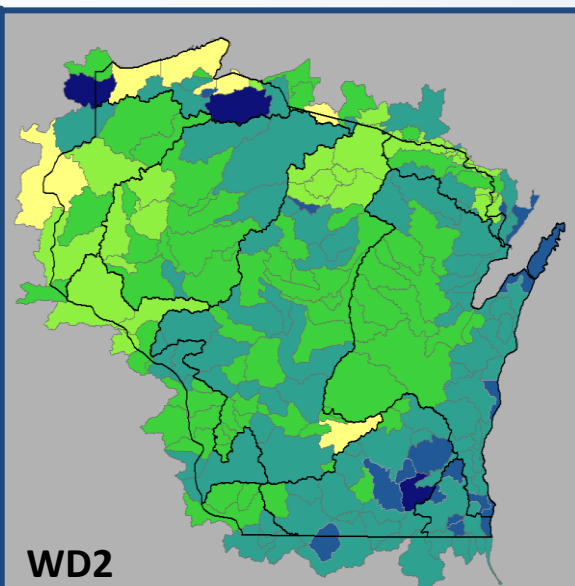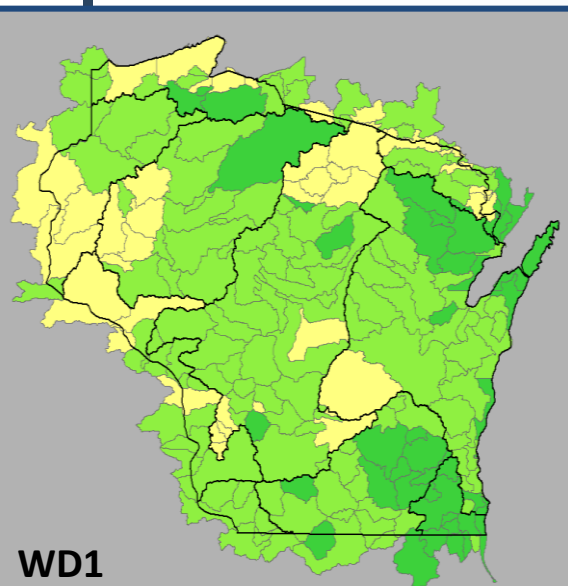
Boolean Occurrence of C3 Warning Day Runoff Events for All Daily Runs

Number of Forecast Runs that have At Least One C3 Runoff Event Simulated for a Given Warning Day

	WD1	WD2	WD3	WDX
Med ::	36	82	74	41
Max ::	64	118	104	58
Min ::	1	1	1	0
Sum ::	7,356	16,305	14,338	7,724

Legend:
- WD1 C3 Bool Events
- WD2 C3 Bool Events
- WD3 C3 Bool Events
- WDX C3 Bool Events

Y-axis: Number of Basins
X-axis: Daily runs with Boolean Warning Day Event Present

Warning Day 1 Boolean Occurrence of C3 Runoff Events

	1 - 15
	16 - 30
	31 - 45
	46 - 60
	61 - 75

	0 - 10% Exceedance
	10 - 90% Exceedance
	90 - 100% Exceedance

	< -1.5 Std. Dev.
	-1.5 - -0.50 Std. Dev.
	-0.50 - 0.50 Std. Dev.
	0.50 - 1.5 Std. Dev.
	1.5 - 2.2 Std. Dev.

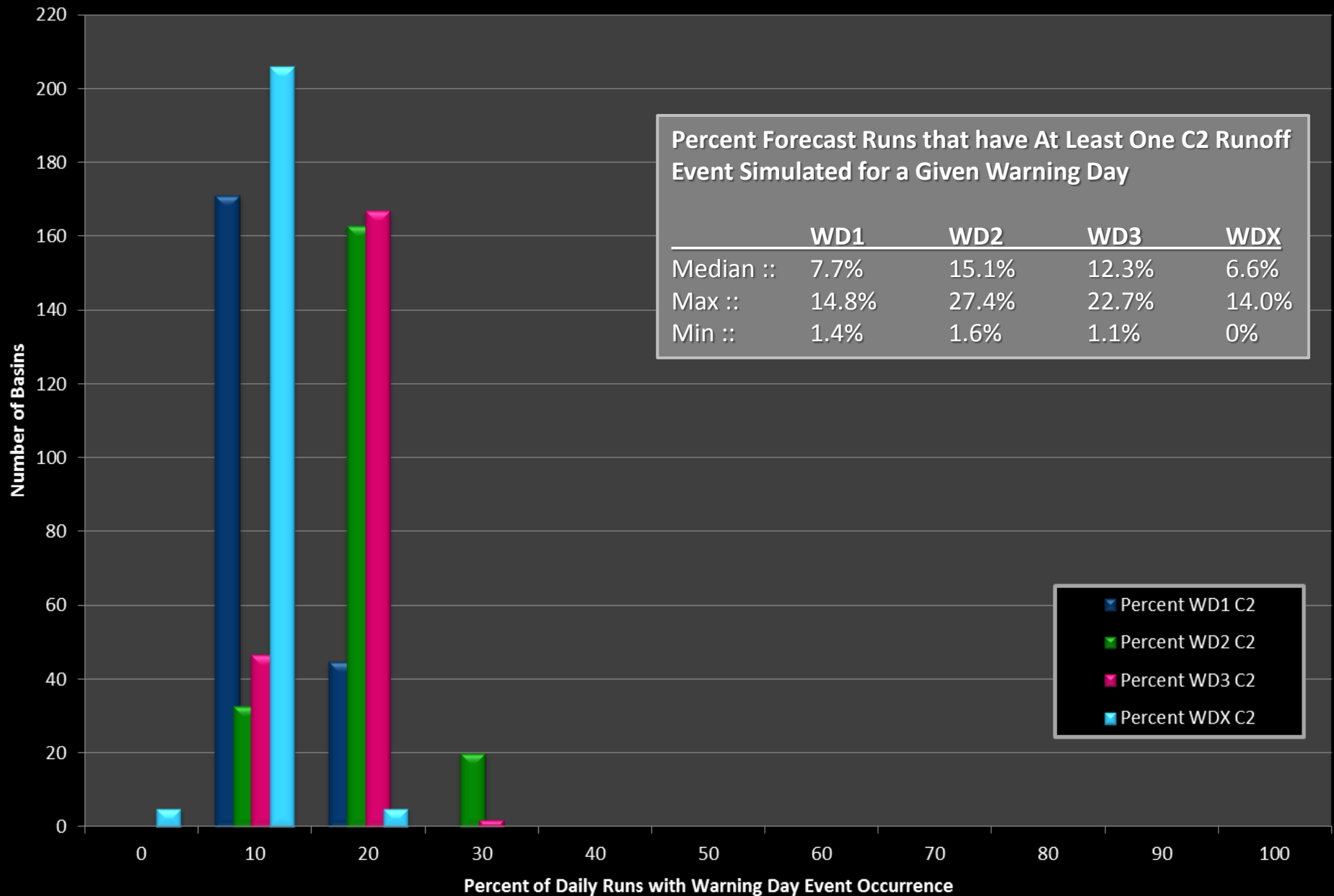| Top 10%			Bottom 10%		
GUNI2	64	17.5%	WI14C	1	0.3%
IL02C	63	17.3%	WI13C	1	0.3%
WMTW3	62	17.0%	WI15C	1	0.3%
BTNW3	59	16.2%	MRNM4	2	0.6%
JHNI2	59	16.2%	WI12C	5	1.4%
FEEI2	57	15.6%	TWFM4	6	1.6%
OMCI2	57	15.6%	MRSW3	6	1.6%
ROMW3	57	15.6%	RRVW3	7	1.9%
WATW3	56	15.3%	VLCM4	8	2.2%
RVLW3	55	15.1%	NIAW3	9	2.5%
DBQI4	53	14.5%	FLOW3	9	2.5%
FATW3	53	14.5%	KFDM4	10	2.7%
JFFW3	53	14.5%	ODAW3	11	3.0%
MTNW3	53	14.5%	LTKW3	11	3.0%
HILW3	52	14.3%	BANM4	11	3.0%
INFW3	52	14.3%	COMW3	12	3.3%
NIPI2	52	14.3%	RHIW3	13	3.6%
LATI2	51	14.0%	KOSM4	13	3.6%
BERW3	50	13.7%	CLKW3	13	3.6%
BLVI4	50	13.7%	BGQW3	13	3.6%
BVDI2	50	13.7%	WTLW3	14	3.8%

Warning Day 2 Boolean Occurrence of C3 Runoff Events

Legend (top map):
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 1.6 Std. Dev.
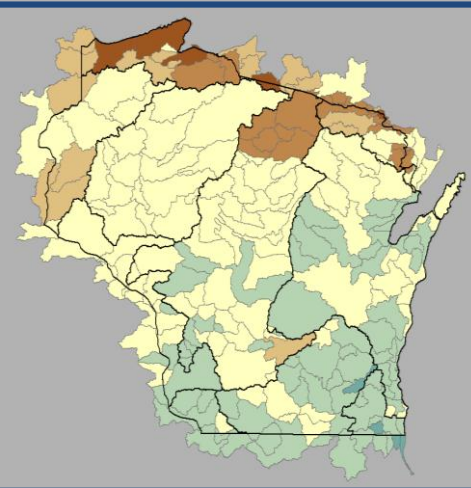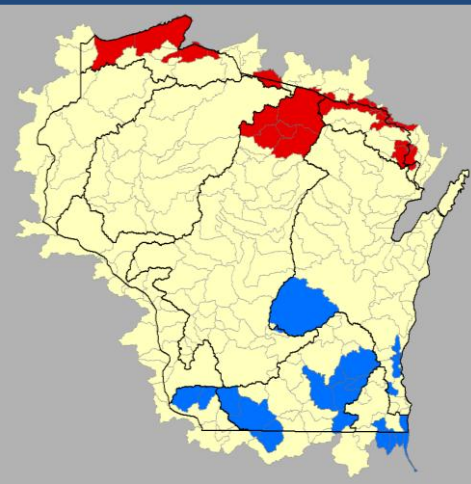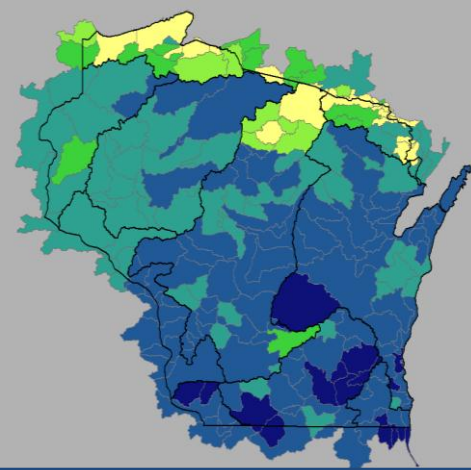
Top 10%			Bottom 10%		
GUNI2	118	32.3%	WI15C	1	0.3%
IL02C	116	31.8%	WI14C	2	0.6%
ROMW3	116	31.8%	WI13C	2	0.6%
WMTW3	116	31.8%	MRNM4	3	0.8%
WATW3	111	30.4%	TWFM4	7	1.9%
BERW3	110	30.1%	VLCM4	11	3.0%
FEEI2	110	30.1%	RRVW3	11	3.0%
JHNI2	108	29.6%	FLOW3	11	3.0%
OMCI2	108	29.6%	NIAW3	12	3.3%
BTNW3	107	29.3%	KFDM4	13	3.6%
FATW3	107	29.3%	BANM4	13	3.6%
MEEW3	107	29.3%	LTKW3	15	4.1%
JFFW3	105	28.8%	CLKW3	15	4.1%
INFW3	103	28.2%	COMW3	16	4.4%
MTNW3	103	28.2%	BGQW3	16	4.4%
FRKW3	101	27.7%	WI12C	18	4.9%
RVLW3	101	27.7%	KOSM4	18	4.9%
CEDW3	100	27.4%	FLRW3	20	5.5%
CLIW3	100	27.4%	WILW3	25	6.9%
DARW3	100	27.4%	KNGW3	25	6.9%
WI01C	100	27.4%	RHIW3	26	7.1%

Warning Day 3 Boolean Occurrence of C3 Runoff Events

Legend (top map):
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 1.6 Std. Dev.
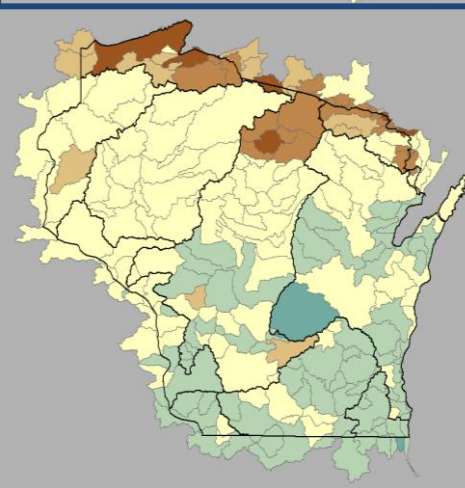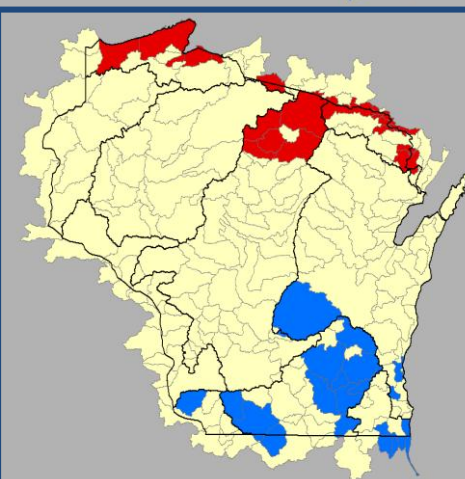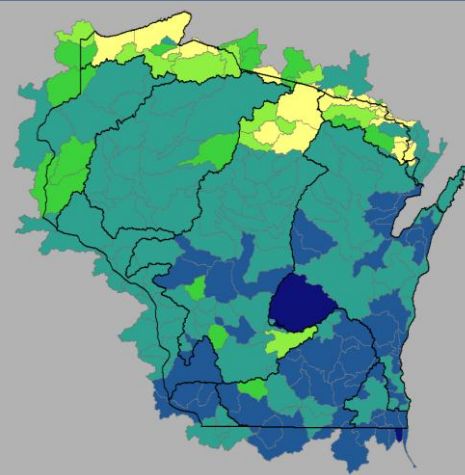
Top 10%			Bottom 10%		
BERW3	104	28.5%	WI15C	1	0.3%
GUNI2	102	28.0%	WI14C	1	0.3%
IL02C	100	27.4%	WI13C	1	0.3%
WMTW3	100	27.4%	MRNM4	2	0.6%
ROMW3	98	26.9%	TWFM4	4	1.1%
FEEI2	95	26.0%	VLCM4	7	1.9%
WATW3	94	25.8%	RRVW3	7	1.9%
FATW3	93	25.5%	LTKW3	9	2.5%
MEEW3	93	25.5%	FLOW3	9	2.5%
OMCI2	93	25.5%	BANM4	9	2.5%
INFW3	92	25.2%	NIAW3	10	2.7%
JHNI2	92	25.2%	KFDM4	10	2.7%
JFFW3	91	24.9%	CLKW3	11	3.0%
BTNW3	90	24.7%	COMW3	12	3.3%
MTNW3	89	24.4%	BGQW3	13	3.6%
WI01C	89	24.4%	WI12C	15	4.1%
CLIW3	88	24.1%	KOSM4	15	4.1%
FRKW3	87	23.8%	FLRW3	15	4.1%
MILW3	87	23.8%	KNGW3	19	5.2%
DARW3	86	23.6%	WILW3	21	5.8%
HCNW3	86	23.6%	TKDW3	22	6.0%

Warning Day X Boolean Occurrence of C3 Runoff Events
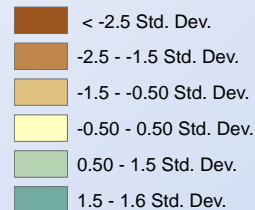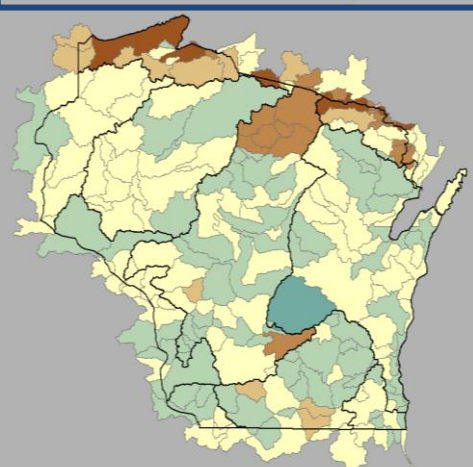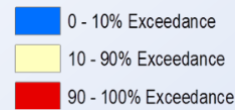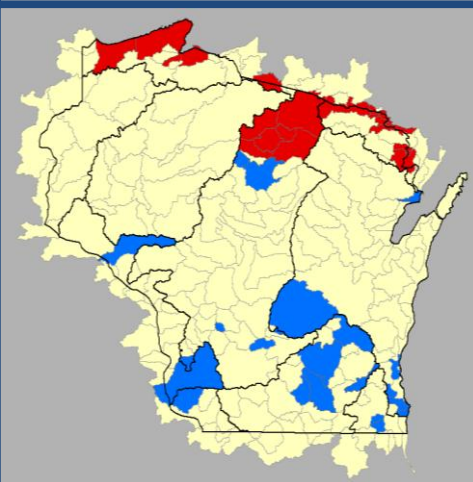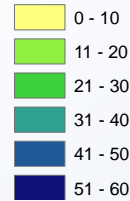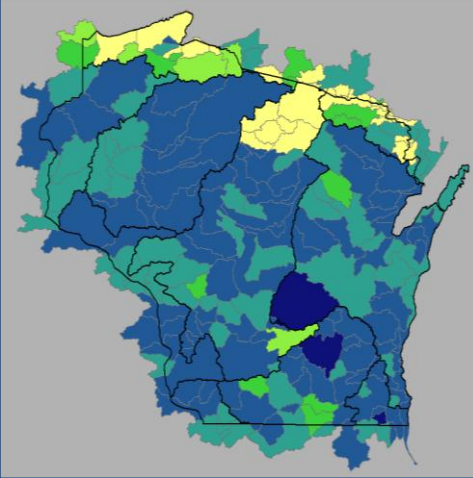
Top 10%			Bottom 10%		
BERW3	58	15.9%	WI15C	0	0%
MILW3	54	14.8%	WI14C	0	0%
WMTW3	54	14.8%	WI13C	0	0%
BTNW3	50	13.7%	MRNM4	0	0%
MEEW3	50	13.7%	TWFM4	1	0.3%
RRLW3	50	13.7%	VLCM4	1	0.3%
ALMW3	49	13.4%	FLRW3	1	0.3%
FULW3	49	13.4%	RRVW3	2	0.6%
GTTI4	49	13.4%	NIAW3	2	0.6%
HCNW3	49	13.4%	KFDM4	2	0.6%
RACW3	49	13.4%	FLOW3	2	0.6%
ROMW3	49	13.4%	COMW3	2	0.6%
WI11C	49	13.4%	RHIW3	3	0.8%
BABW3	48	13.2%	LTKW3	3	0.8%
FRKW3	48	13.2%	KNGW3	3	0.8%
HILW3	48	13.2%	CLKW3	3	0.8%
INFW3	48	13.2%	BGQW3	3	0.8%
NMSW3	48	13.2%	BANM4	3	0.8%
STEW3	48	13.2%	WILW3	4	1.1%
TRIW3	48	13.2%	KOSM4	4	1.1%
WI02C	48	13.2%	TKDW3	5	1.4%

Percent Daily Forecast Runs with C3 Runoff Event Boolean Occurrence for each Warning Day
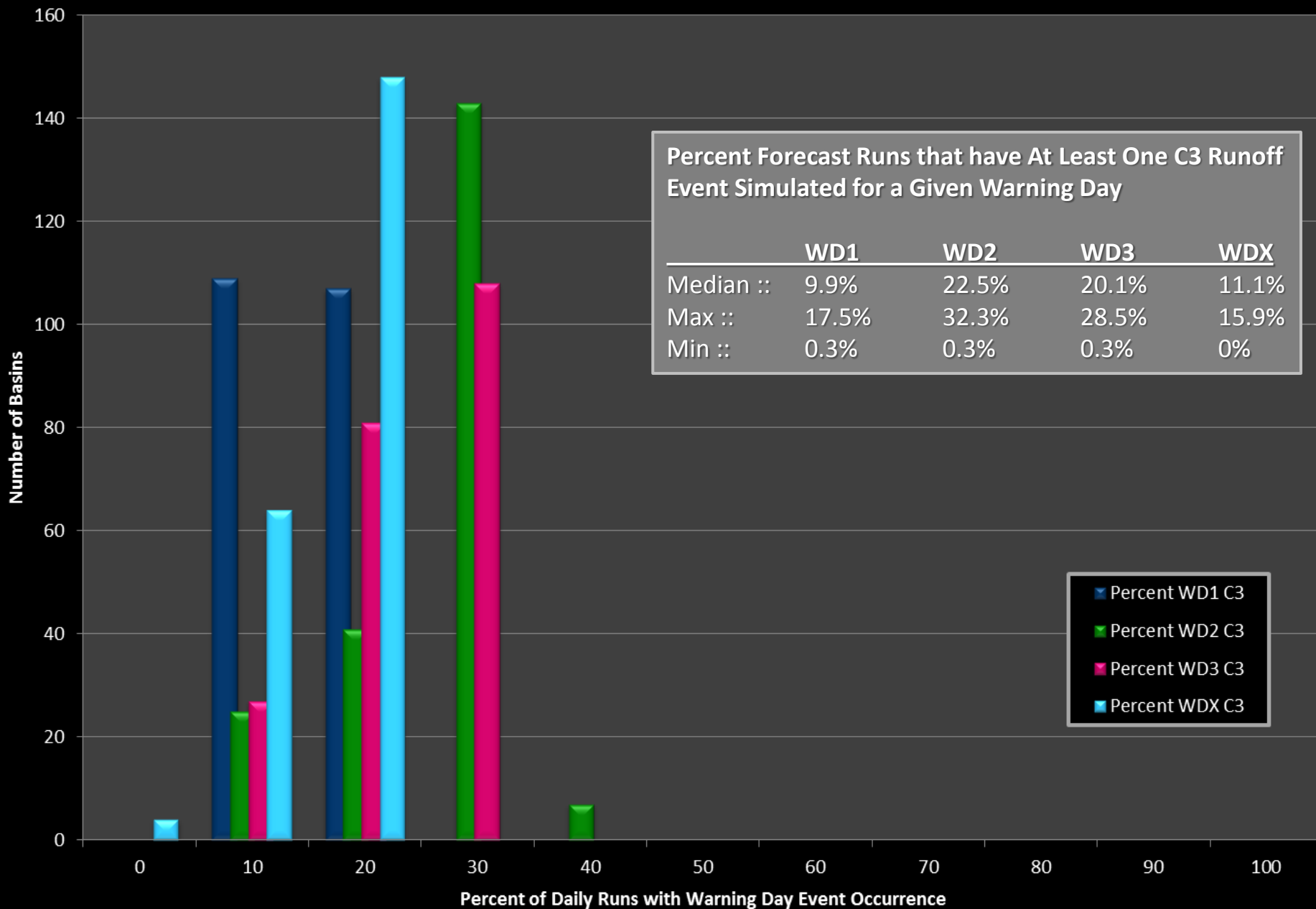
Percent Forecast Runs that have At Least One C3 Runoff Event Simulated for a Given Warning Day

	WD1	WD2	WD3	WDX
Median ::	9.9%	22.5%	20.1%	11.1%
Max ::	17.5%	32.3%	28.5%	15.9%
Min ::	0.3%	0.3%	0.3%	0%

Legend:
- Percent WD1 C3
- Percent WD2 C3
- Percent WD3 C3
- Percent WDX C3

Y-axis: Number of Basins

X-axis: Percent of Daily Runs with Warning Day Event Occurrence

Percent Daily Forecast Runs with C3 Runoff Event Boolean Occurrence for each Warning Day

WD1

WD2

WD3

WDX

Legend:
- 0%
- 0.1 - 5%
- 5 - 10%
- 10 - 15%
- 15 - 20%
- 20 - 25%
- 25 - 30%
- 30 - 35%
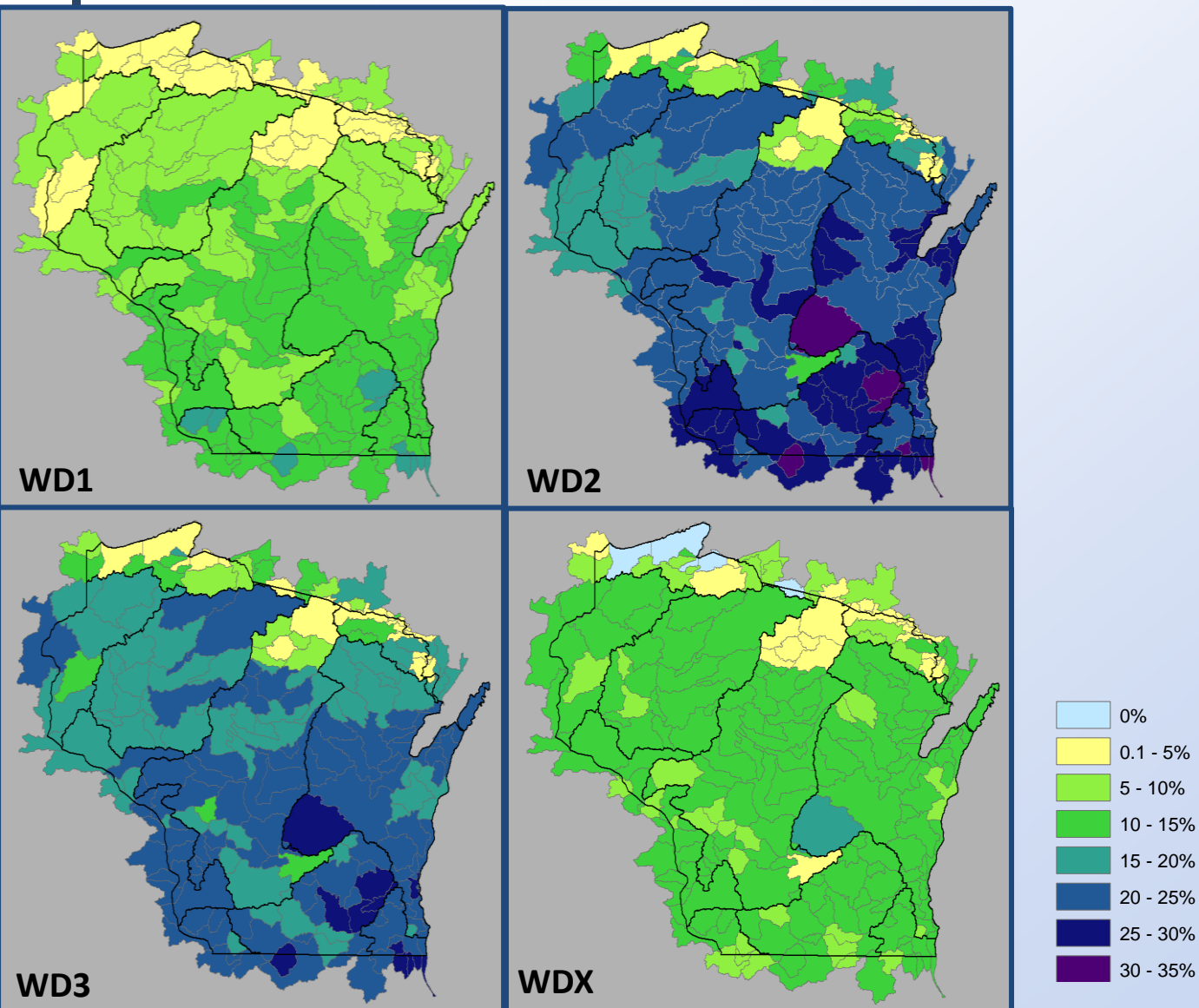
Boolean Occurrence of Any Warning Day Runoff Events for All Daily Runs

Number of Forecast Runs that have At Least One (Any Cat) Runoff Event Simulated for a Given Warning Day

	WD1	WD2	WD3	WDX
Med ::	64	118	104	59
Max ::	104	171	145	77
Min ::	7	7	5	0
Sum ::	13,066	24,004	21,079	11,614

Legend:
- WD1 Any Bool
- WD2 Any Bool
- WD3 Any Bool
- WDX Any Bool

Y-axis: Number of Basins

X-axis: Daily Runs with Boolean Warning Day Runoff Event Present

Warning Day 1 Boolean Occurrence of Any Runoff Event

| 7 - 20 |
| 21 - 40 |
| 41 - 60 |
| 61 - 80 |
| 81 - 100 |
| 101 - 120 |

| 0 - 10% Exceedance |
| 10 - 90% Exceedance |
| 90 - 100% Exceedance |

| < -2.5 Std. Dev. |
| -2.5 - -1.5 Std. Dev. |
| -1.5 - -0.50 Std. Dev. |
| -0.50 - 0.50 Std. Dev. |
| 0.50 - 1.5 Std. Dev. |
| 1.5 - 2.2 Std. Dev. |

Top 10%			Bottom 10%		
FATW3	104	28.5%	WI15C	7	1.9%
JFFW3	104	28.5%	WI14C	7	1.9%
WMTW3	104	28.5%	WI13C	7	1.9%
IL02C	102	28.0%	MRNM4	7	1.9%
WATW3	102	28.0%	WI12C	16	4.4%
INFW3	101	27.7%	RRVW3	19	5.2%
FEEI2	98	26.9%	NIAW3	23	6.3%
WI01C	93	25.5%	LTKW3	23	6.3%
JHNI2	92	25.5%	TWFM4	24	6.6%
OMCI2	91	24.9%	RHIW3	25	6.9%
ROMW3	91	24.9%	KNGW3	25	6.9%
GUNI2	90	24.7%	CLKW3	25	6.9%
MUKW3	90	24.7%	BANM4	25	6.9%
HUSW3	89	24.4%	VLCM4	27	7.4%
NIPI2	88	24.1%	FLOW3	27	7.4%
BVDI2	86	23.6%	KFDM4	28	7.7%
MILW3	86	23.6%	BGQW3	28	7.7%
NMSW3	86	23.6%	KOSM4	29	8.0%
RACW3	86	23.6%	FLRW3	29	8.0%
WI02C	86	23.6%	TKDW3	30	8.2%
RUSI2	85	23.3%	COMW3	30	8.2%

Warning Day 2 Boolean Occurrence of Any Runoff Event
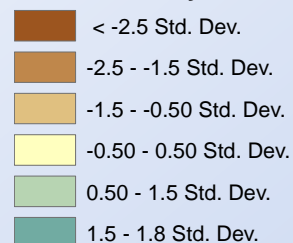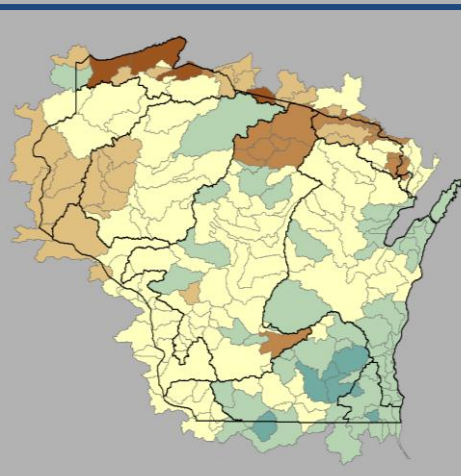
Top 10%			Bottom 10%		
FATW3	171	46.9%	WI14C	7	1.9%
WMTW3	165	45.2%	WI15C	8	2.2%
WATW3	164	44.9%	WI13C	8	2.2%
INFW3	163	44.7%	MRNM4	11	3.0%
JFFW3	163	44.7%	WI12C	32	8.8%
FEEI2	161	44.1%	RRVW3	32	8.8%
MUKW3	160	43.8%	TWFM4	36	9.9%
ROMW3	158	43.3%	LTKW3	36	9.9%
IL02C	156	42.7%	VLCM4	41	11.2%
WI02C	152	41.6%	FLOW3	41	11.2%
NMSW3	151	41.4%	NIAW3	42	11.5%
MTNW3	150	41.1%	BANM4	42	11.5%
GUNI2	149	40.8%	CLKW3	44	12.1%
RUSI2	149	40.8%	KOSM4	45	12.3%
WI01C	149	40.8%	COMW3	45	12.3%
BRGW3	148	40.6%	KNGW3	46	12.6%
FRKW3	148	40.6%	KFDM4	47	12.9%
MEEW3	148	40.6%	RHIW3	49	13.4%
OMCI2	148	40.6%	WILW3	50	13.7%
HUSW3	146	40.0%	FLRW3	50	13.7%
JHNI2	146	40.0%	BGQW3	50	13.7%

Warning Day 3 Boolean Occurrence of Any Runoff Event
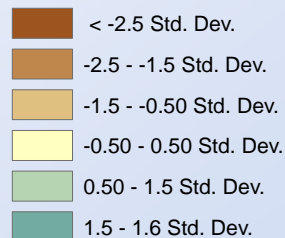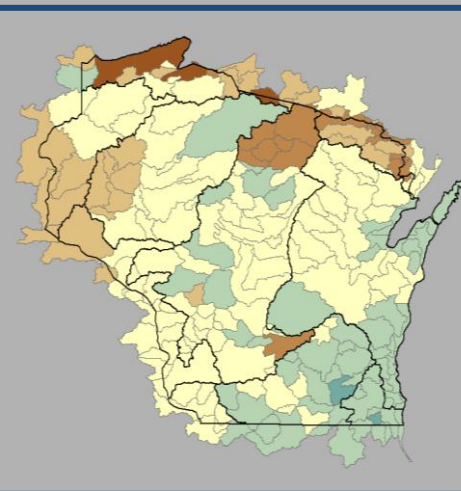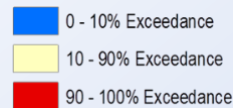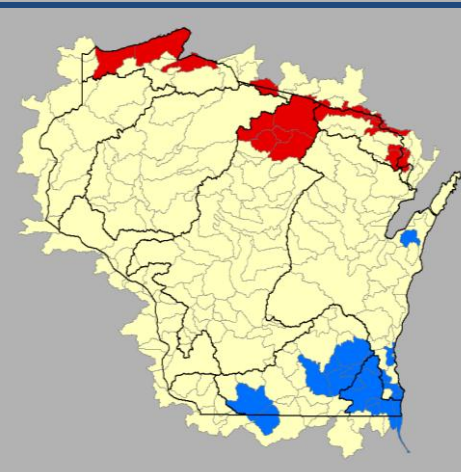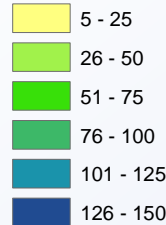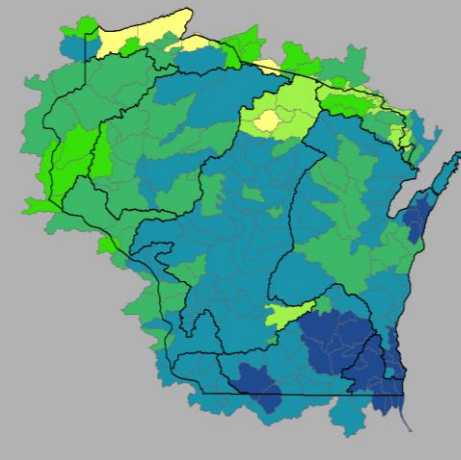
| 5 - 25 |
| 26 - 50 |
| 51 - 75 |
| 76 - 100 |
| 101 - 125 |
| 126 - 150 |

| 0 - 10% Exceedance |
| 10 - 90% Exceedance |
| 90 - 100% Exceedance |

| < -2.5 Std. Dev. |
| -2.5 - -1.5 Std. Dev. |
| -1.5 - -0.50 Std. Dev. |
| -0.50 - 0.50 Std. Dev. |
| 0.50 - 1.5 Std. Dev. |
| 1.5 - 1.6 Std. Dev. |

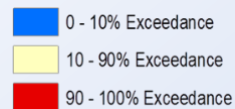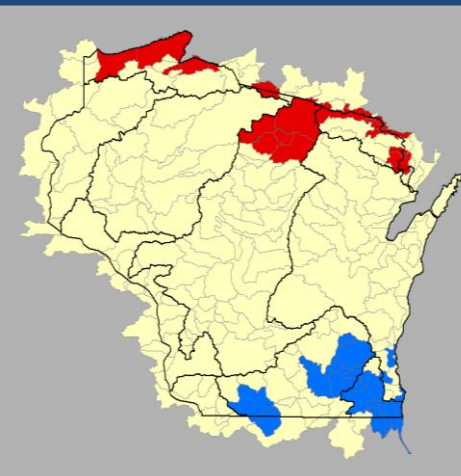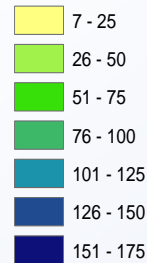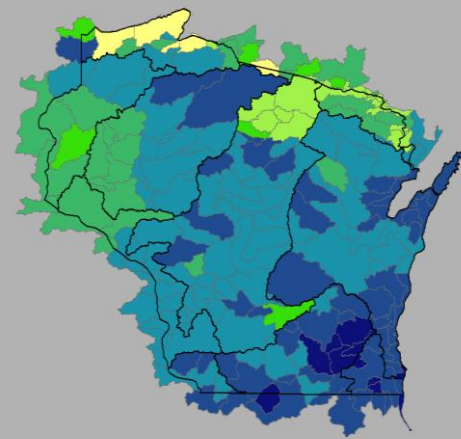| Top 10%			Bottom 10%		
FATW3	145	39.7%	WI13C	5	1.4%
WMTW3	144	39.5%	WI14C	5	1.4%
INFW3	141	38.6%	WI15C	6	1.6%
WATW3	141	38.6%	MRNM4	6	1.6%
IL02C	139	38.1%	RRVW3	25	6.9%
JFFW3	139	38.1%	WI12C	27	7.4%
FEEI2	138	37.8%	TWFM4	28	7.7%
WI02C	138	37.8%	LTKW3	28	7.7%
ROMW3	137	37.5%	FLOW3	32	8.8%
MUKW3	136	37.3%	VLCM4	33	9.0%
RUSI2	134	36.7%	BANM4	33	9.0%
GUNI2	132	36.2%	NIAW3	34	9.3%
MEEW3	132	36.2%	KOSM4	35	9.6%
NMSW3	132	36.2%	COMW3	35	9.6%
RACW3	132	36.2%	CLKW3	36	9.9%
WI01C	132	36.2%	KNGW3	37	10.1%
WKEW3	131	35.9%	KFDM4	37	10.1%
BRGW3	130	35.6%	BGQW3	40	11.0%
KEWW3	130	35.6%	FLRW3	41	11.2%
FRKW3	129	35.3%	RHIW3	42	11.5%
MTNW3	129	35.3%	WILW3	44	12.1%

Warning Day X Boolean Occurrence of Any Runoff Event
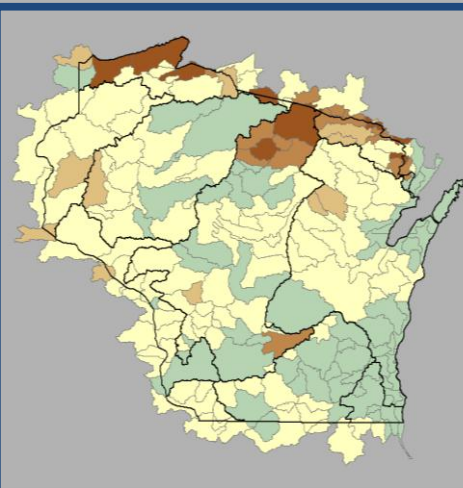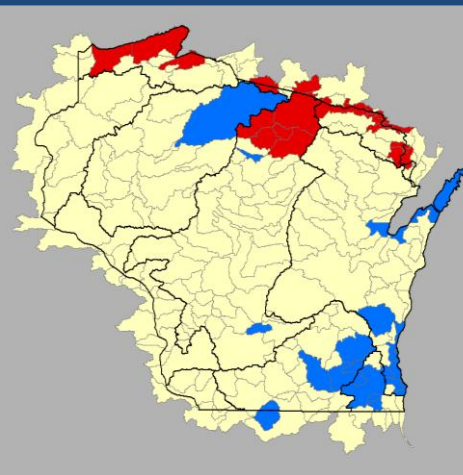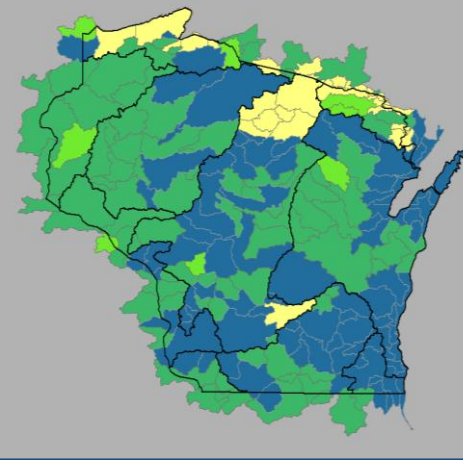
	Top 10%			Bottom 10%	
WI02C	77	21.1%	WI15C	0	0%
WMTW3	77	21.1%	WI14C	0	0%
RACW3	76	20.8%	WI13C	0	0%
MEEW3	75	20.6%	MRNM4	0	0%
INFW3	74	20.3%	RRVW3	3	0.8%
NMSW3	74	20.3%	LTKW3	3	0.8%
FATW3	73	20.0%	TWFM4	5	1.4%
FRKW3	73	20.0%	VLCM4	6	1.6%
WATW3	73	20.0%	FLOW3	6	1.6%
WAUW3	73	20.0%	COMW3	6	1.6%
WI03C	73	20.0%	CLKW3	6	1.6%
WI09C	73	20.0%	BANM4	6	1.6%
BGFW3	72	19.7%	FLRW3	7	1.9%
WI04C	72	19.7%	KOSM4	8	2.2%
BABW3	71	19.5%	KNGW3	8	2.2%
BRGW3	71	19.5%	NIAW3	9	2.5%
FEEI2	71	19.5%	KDFM4	9	2.5%
MUKW3	71	19.5%	RHIW3	10	2.7%
ROMW3	71	19.5%	WILW3	11	3.0%
SPDW3	71	19.5%	BGQW3	11	3.0%
WI08C	71	19.5%	PAUM4	12	3.3%

Legend (top map):
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

Legend (middle map):
- 0 - 10% Exceedance
- 10 - 90% Exceedance
- 90 - 100% Exceedance

Legend (bottom map):
- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.2 Std. Dev.

Percent Daily Forecast Runs with Any Category Boolean Occurance for each Warning Day

Percent Forecast Runs that have At Least One Runoff Event Simulated for a Given Warning Day

	WD1	WD2	WD3	WDX
Median ::	17.3%	32.3%	28.5%	16.2%
Max ::	28.5%	46.9%	39.7%	21.1%
Min ::	1.9%	1.9%	1.4%	0%

Number of Basins

Percent Daily Runs with Warning Day Event Occurrence

- Percent WD1 Any Bool
- Percent WD2 Any Bool
- Percent WD3 Any Bool
- Percent WDX Any Bool
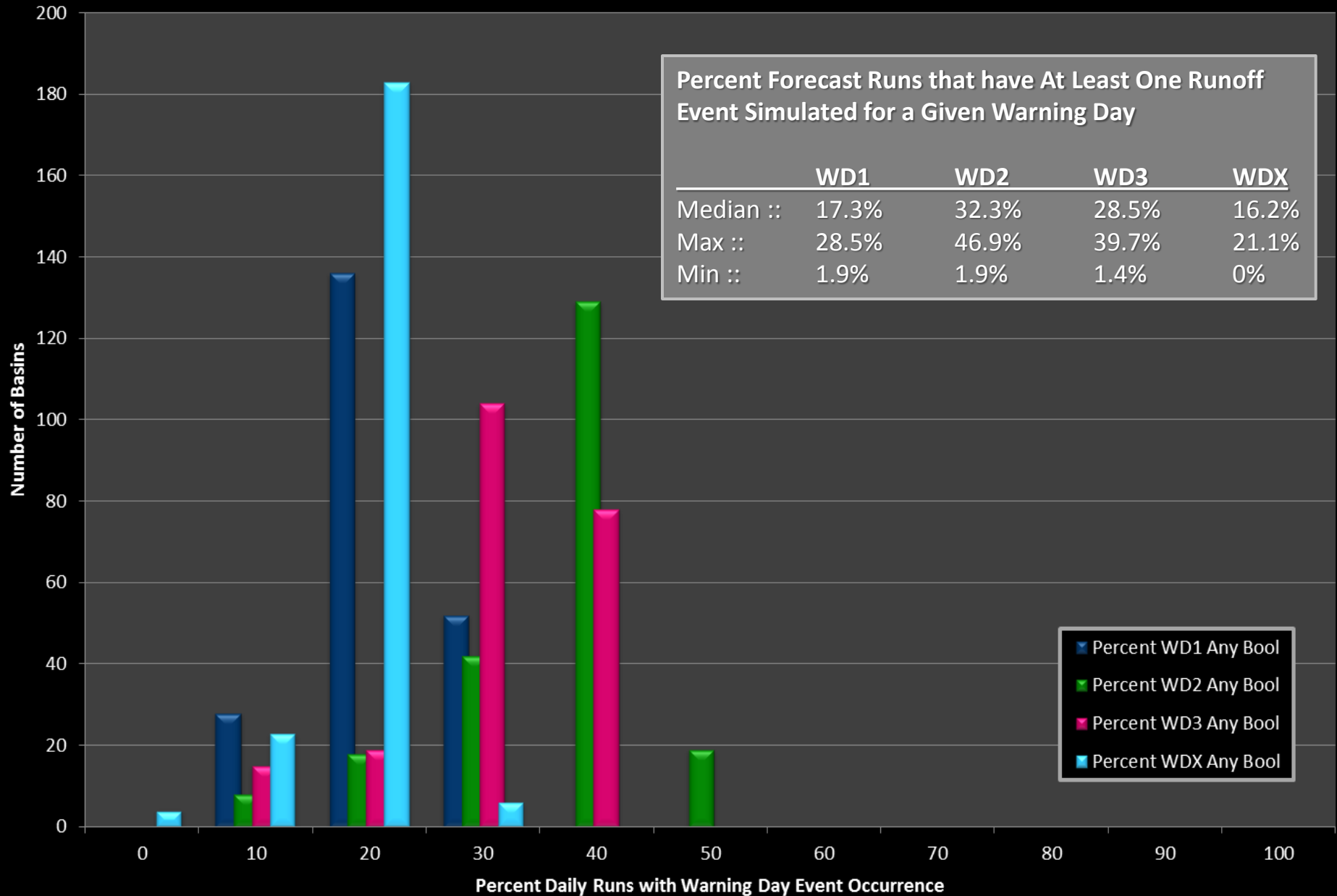
Percent Daily Forecast Runs with Any Runoff Event Boolean Occurrence for each Warning Day
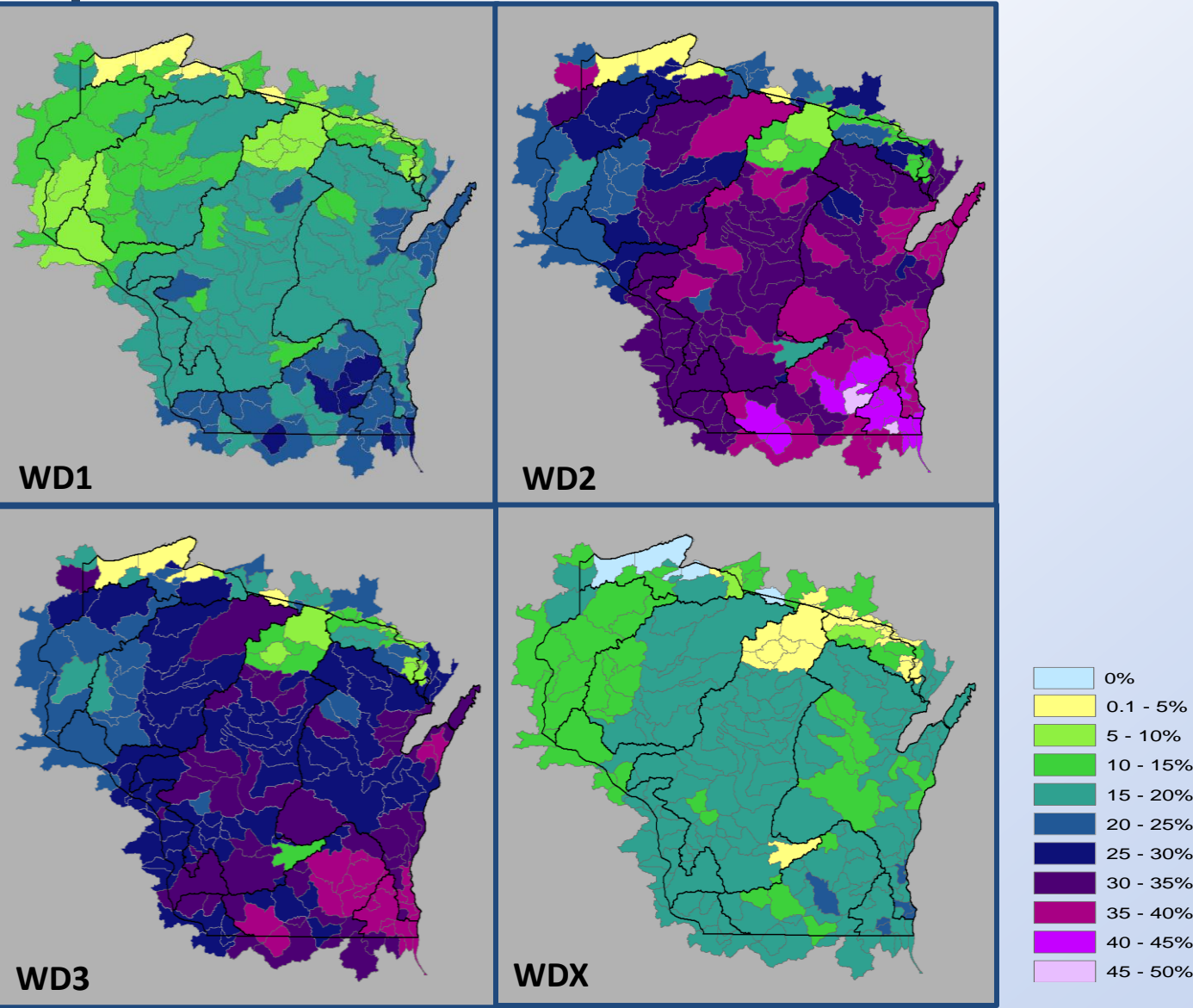
Percent Daily Forecast Runs with Runoff Event Boolean Occurrence for each Warning Day
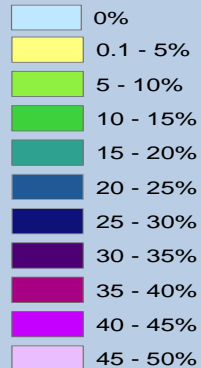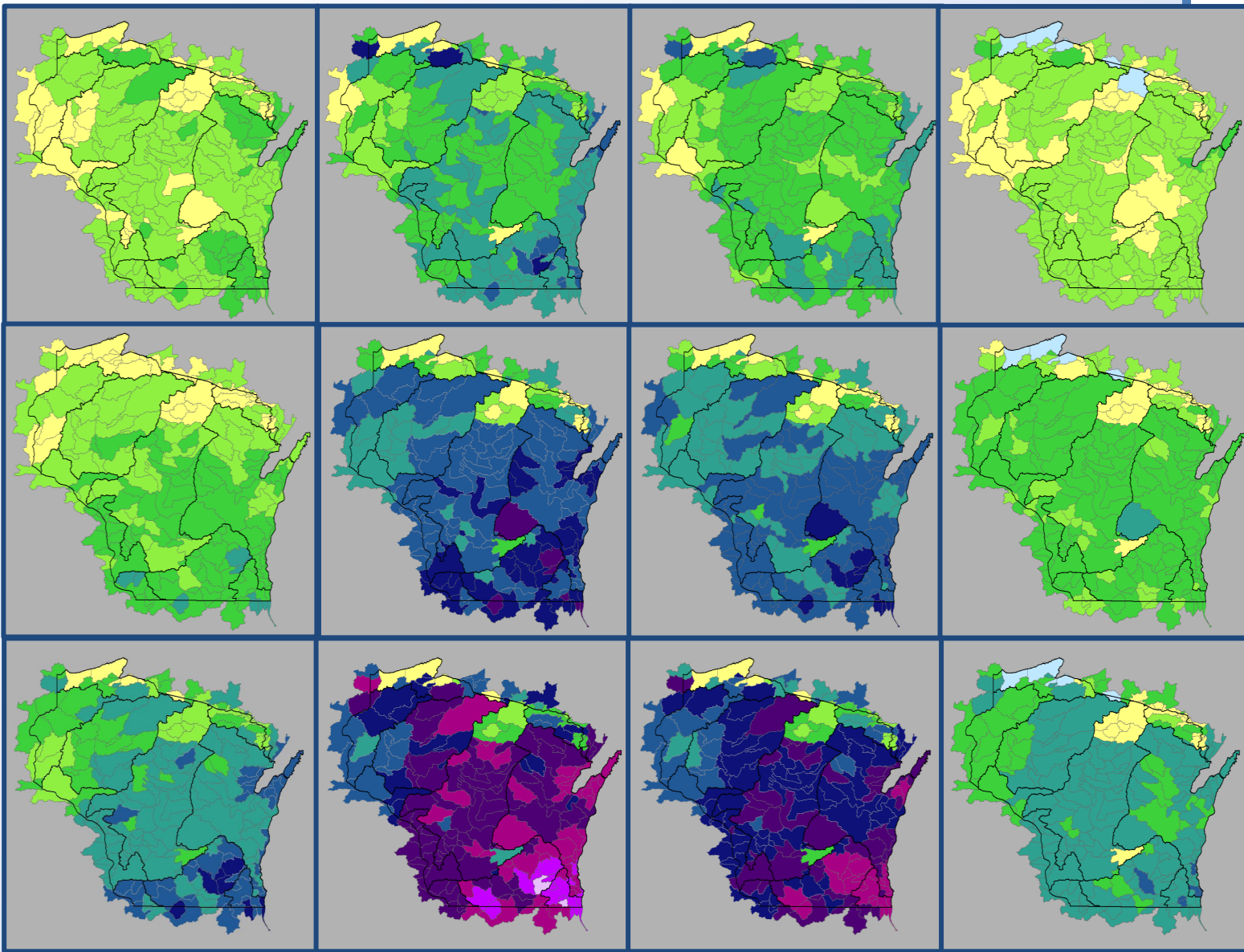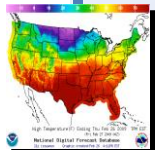
Warning Day Summary

➤ **Median Percent of Warning Day Boolean Runoff Event Presence ::**

    ➤ *WD2 and WD3 have the highest incidence of Runoff Events in All, C2, and C3*

    ➤ *WD1 = ALL :: 17.3%   C3 :: 9.9%   C2 :: 7.7%*

    ➤ *WD2 = ALL :: 32.3%   C3 :: 22.5%   C2 :: 15.1%*

    ➤ *WD3 = ALL :: 28.5%   C3 :: 20.1%   C2 :: 12.3%*

    ➤ *WDX = ALL :: 16.2%   C3 :: 11.1%   C2 :: 6.6%*
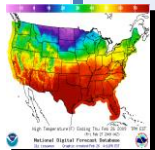
Data Analysis Overview

1. **The following model parameters were analyzed:**
   - *Forecast Precipitation*   *(FMAP)*
   - *Rain+Melt*   *(RAIM)*
   - *SAC-SMA Interflow Runoff*   *(INTRO)*
   - *SAC-SMA Upper Zone Tension Water Deficit*   *(UZTWD)*

2. **Analysis of Simulated Runoff Events**
   - *Review Raw Simulated Events*
     - Number of events , Amount of runoff, and Total Time per Risk Category

   - *Review in Boolean Perspective*
     - Does period in question have at least one event = 1, otherwise = 0

   - *Review in Warning Day Perspective*
     - Equivalent to RRAF map hosted by WI DATCP webpage

   - ***Review in Runoff Type Perspective***
     - **Look at impacts of runoff type (rainfall, snowmelt, or both)**

Recall Runoff Types

➢ **Every simulated runoff event flagged with a runoff type**

  ➢ *F0 :: All Rainfall*

  ➢ *F1 :: Mix of Rainfall and Snowmelt*

  ➢ *F2 :: All Snowmelt*

Analysis Accumulated Simulated Runoff Events by Runoff Type

Number Runoff Events (C2 + C3) for each Runoff Type

	Rain	Mix	Snowmelt	All
Median ::	105	36	48	198
Max ::	207	73	84	287
Min ::	3	3	0	9
Sum ::	22,530	7,889	9,970	40,389

Legend:
- All Rain
- All Mix
- All Snowmelt
- All Events

Y-axis: Number of Basins

X-axis: Number of Events

Percent of Analysis Accumulated Runoff Events by Runoff Type

Percent of Runoff Events (C2 + C3) for each Basin Stratified by Runoff Type

	All Rain	Mix	All Snowmelt
Median ::	54%	20%	25%
Max ::	78%	57%	36%
Min ::	18%	6%	0%

Legend:
- All Rain
- All Mix
- All Snowmelt

Y-axis: Number of Basins
X-axis: Percent All Events
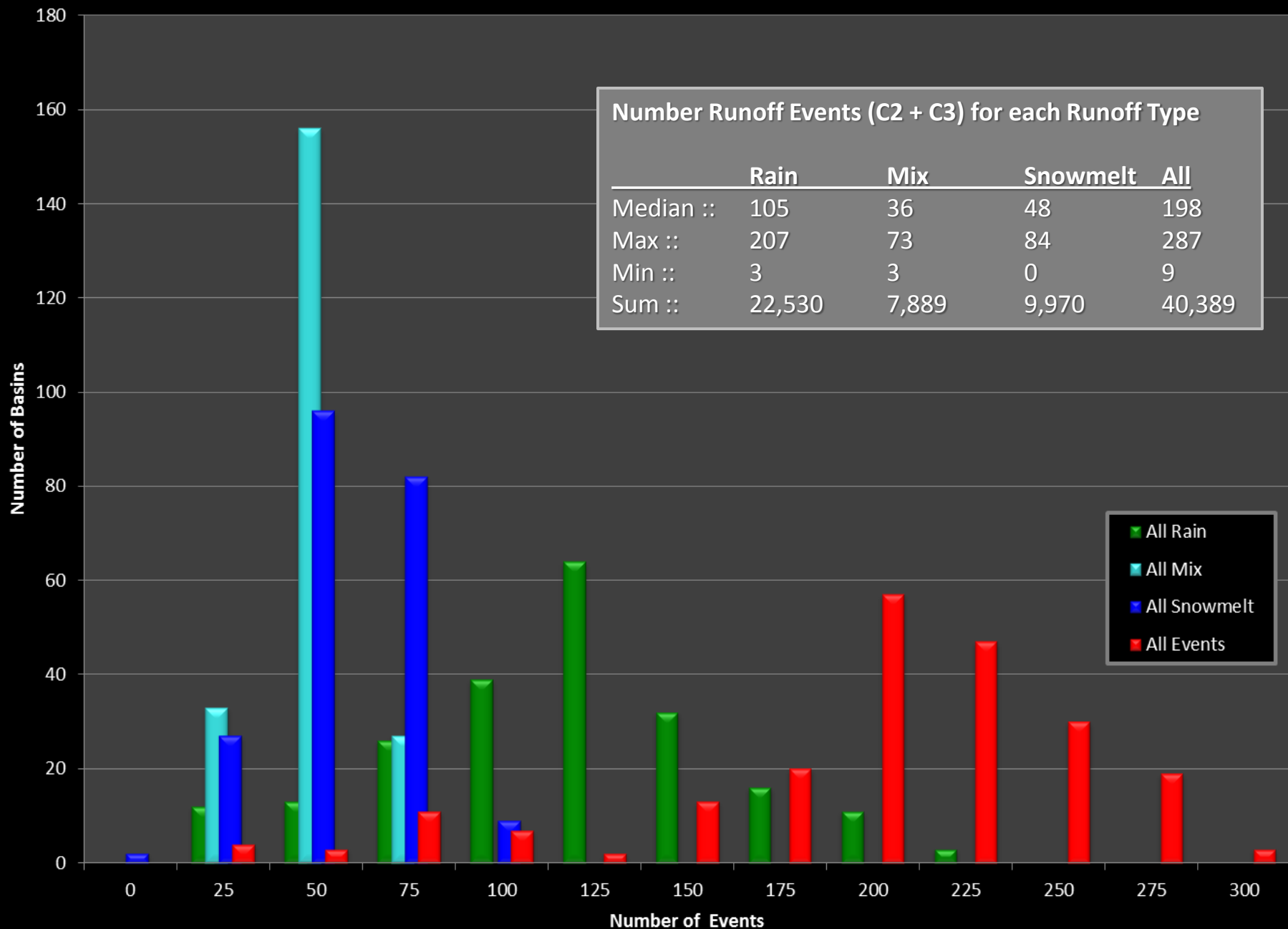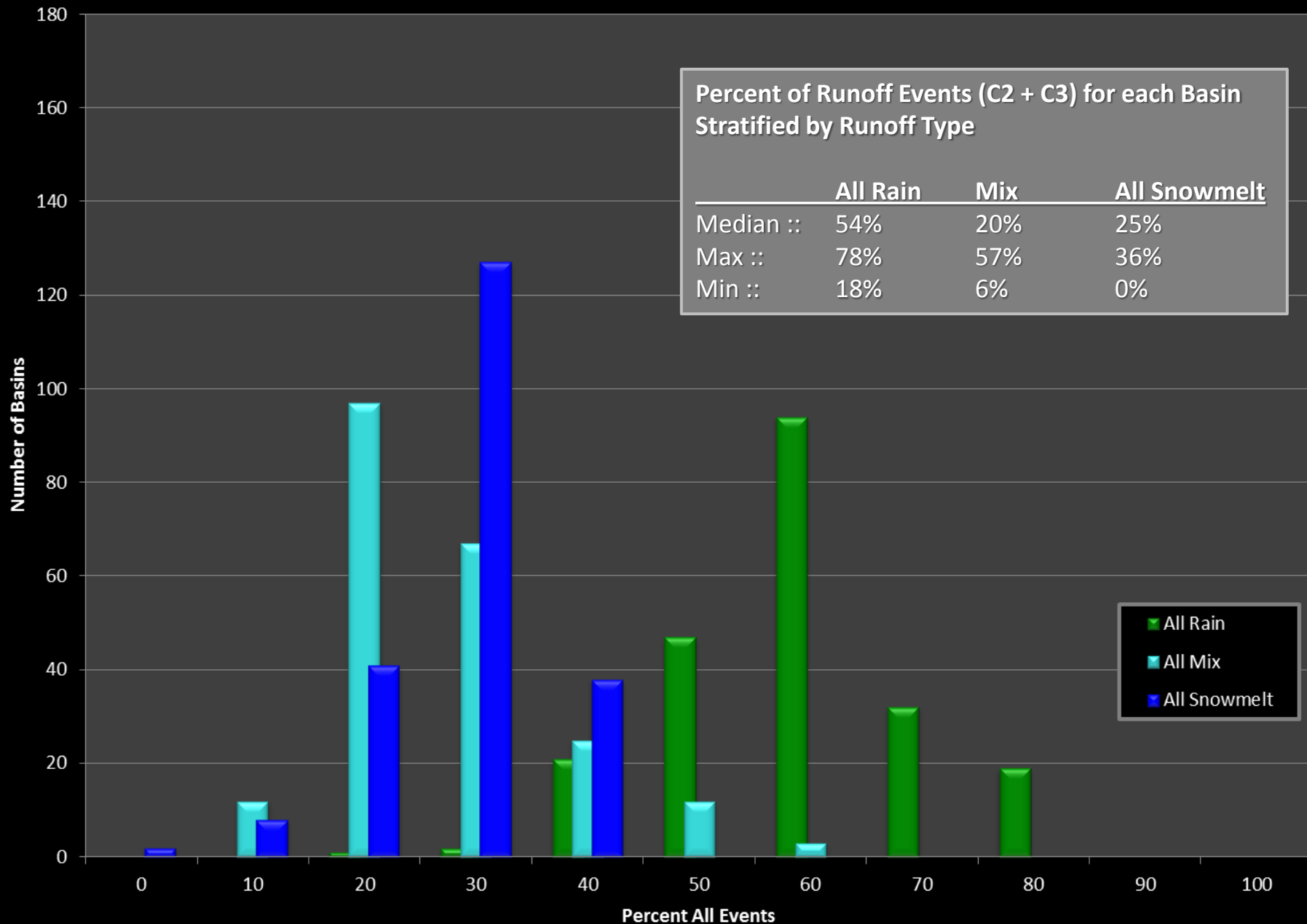
Number of Events & Percent of Total Runoff Events by Runoff Type
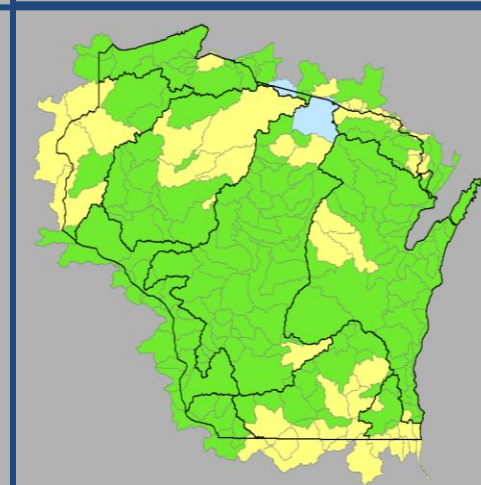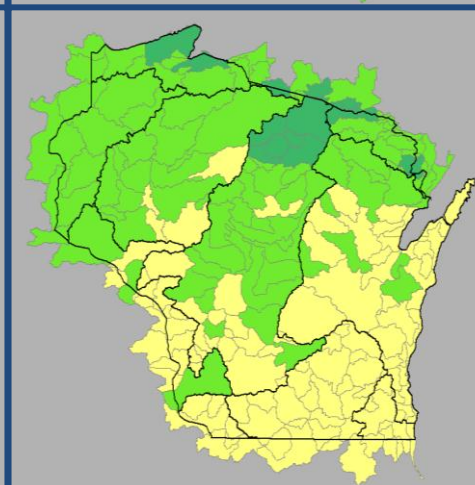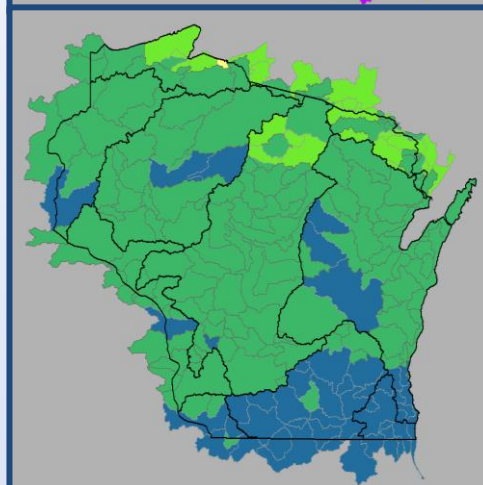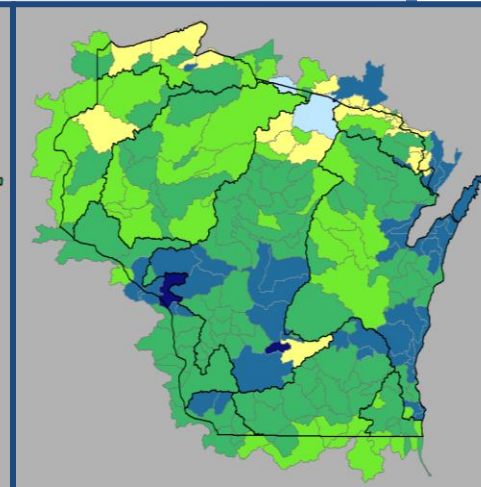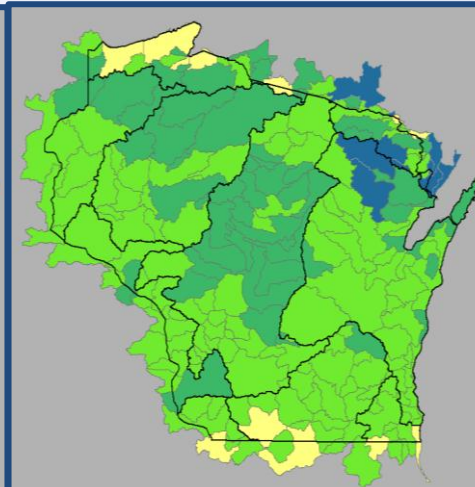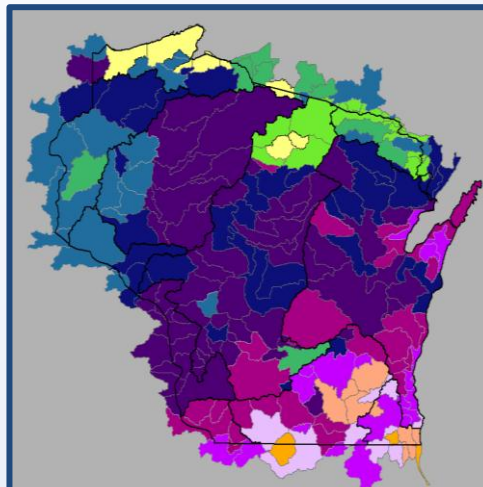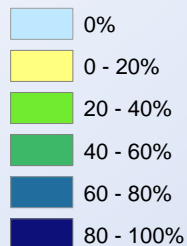
Number of Total Runoff Events Stratified by Runoff Type

Rainfall Only

Mix

Snowmelt Only

National Weather Service

Protecting Lives and Property

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.4 Std. Dev.

< -2.5 Std. Dev.
-2.5 - -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.
> 2.5 Std. Dev.

< -2.5 Std. Dev.
-2.5 - -1.5 Std. Dev.
-1.5 - -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.1 Std. Dev.

Analysis Accumulated Number of Runoff Events by Runoff Type and Category

All Runoff Types

Rainfall Only

Mix

Snowmelt Only

C2

C3

All Events

Legend:
- 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 220
- 221 - 240
- 241 - 260
- 261 - 280
- 281 - 300

Runoff Type Number Events Summary

➢ **Most Runoff Events are generated due to rainfall only**

  ➢ *Median Percent of Runoff Events Caused by ::*

    ➢ **Rainfall Only = 54%**

    ➢ **Mix = 20%**

    ➢ **Snowmelt Only = 25%**

➢ **Basins with highest number of Rainfall only events are in southern Wisconsin**

➢ **Basins with highest number of Mix events are in central to northeastern Wisconsin**

➢ **Basins with highest number of Snowmelt only events are in the southern half of the state**

Analysis Accumulated Simulated Event Runoff by Runoff Type

Event Runoff for each Basin by Runoff Type

	Rain	Mix	Snowmelt	All
Median ::	162	122	34	376
Max ::	506	1,197	229	1,587
Min ::	0.1	0.2	0	0.6
Sum ::	38,828	47,826	10,321	96,975

Legend:
- All Rain
- All Mix
- All Snowmelt
- All Events

Y-axis: Number of Basins

X-axis: Analysis Accumulated Runoff (mm)

Percent of Analysis Accumulated Event Runoff by Runoff Type

Percent of Total Event Runoff for each Basin
Stratified by Runoff Type

	All Rain	Mix	All Snowmelt
Median ::	40%	49%	9%
Max ::	88%	88%	25%
Min ::	7%	8%	0%

All Rain
Mix
All Snowmelt

Number of Basins

Percent Total Event Runoff

Runoff & Percent of Total Runoff Events by Runoff Type
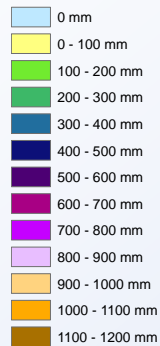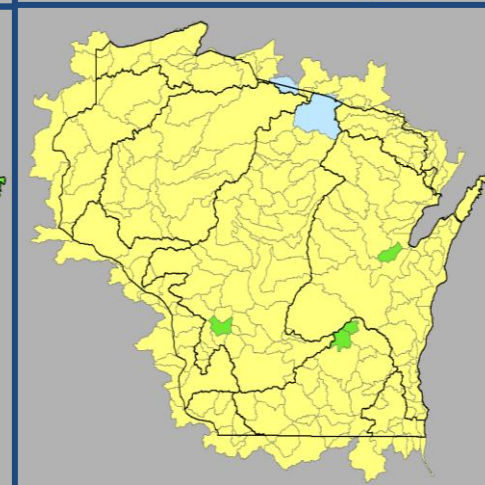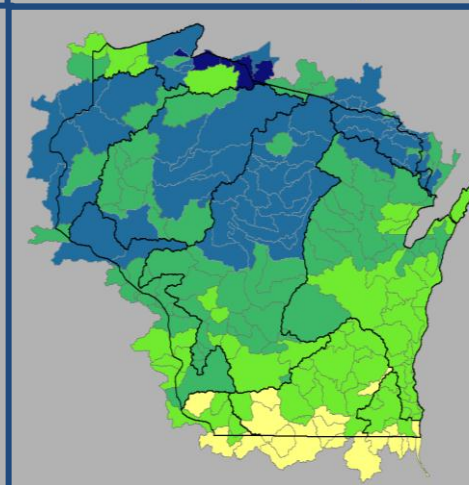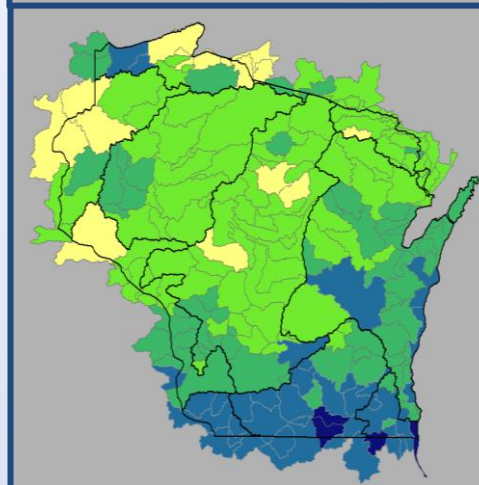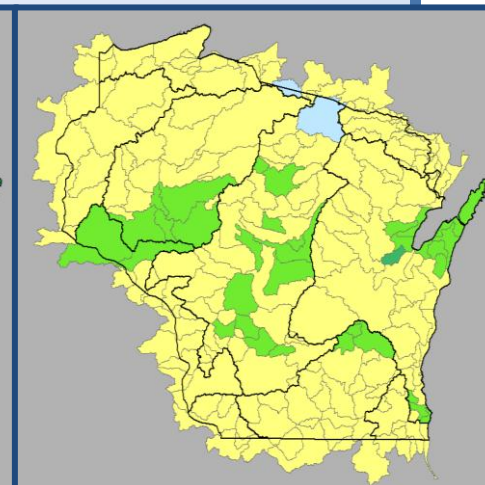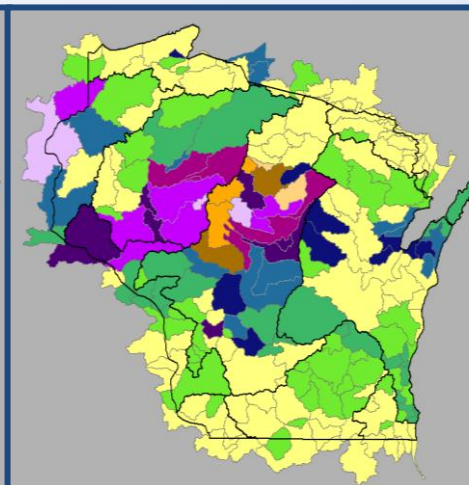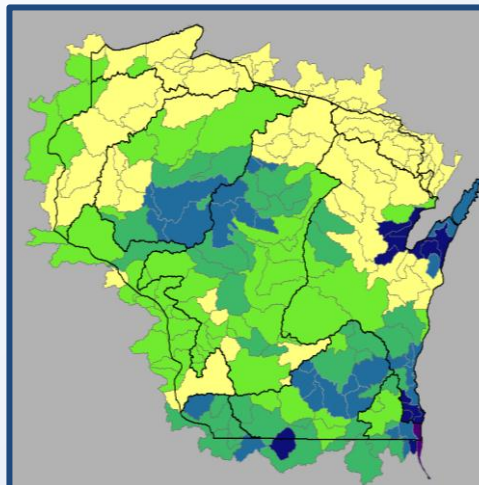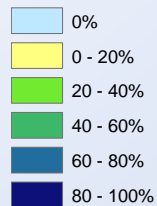
Analysis Accumulated Event Runoff Stratified by Runoff Type

Rainfall Only **Mix** **Snowmelt Only**

National Weather Service

Protecting Lives and Property

0 - 10% Exceedance
10 - 90% Exceedance
90 - 100% Exceedance

< -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.

< -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.

< -0.50 Std. Dev.
-0.50 - 0.50 Std. Dev.
0.50 - 1.5 Std. Dev.
1.5 - 2.5 Std. Dev.
> 2.5 Std. Dev.

Analysis Accumulated Event Runoff by Runoff Type and Category

All Runoff Types

Rainfall Only

Mix

Snowmelt Only

C2

C3

All Events

Legend:
- 0 mm
- 0 - 100 mm
- 100 - 200 mm
- 200 - 300 mm
- 300 - 400 mm
- 400 - 500 mm
- 500 - 600 mm
- 600 - 700 mm
- 700 - 800 mm
- 800 - 900 mm
- 900 - 1000 mm
- 1000 - 1100 mm
- 1100 - 1200 mm
- 1200 - 1300 mm
- 1300 - 1400 mm
- 1400 - 1500 mm
- 1500 - 1600 mm

Runoff Type Event Runoff Summary

➤ **Most of a basin's runoff is generated from rainfall only events**

  ➤ *Median Event Runoff :: Rain = 162 mm, Mix = 122 mm, Snowmelt = 34 mm*

➤ **However the max basin Event Runoff is derived from mix events**

  ➤ *Maximum Event Runoff :: Rain = 506 mm, Mix = 1197 mm, Snowmelt = 229 mm*

➤ **Percentage of basin Event Runoff is also led by the mix events**

  ➤ *Median percentage of Total Event Runoff :: Rain = 40%, Mix = 49%, Snowmelt = 9%*

➤ **As expected Rainfall events have a higher % of total percentage of event runoff in southern Wisconsin, whereas mix events are much higher in central and northern parts of the state**

➤ **Overall Notes on Runoff Type ::**

  ➤ *Rainfall events dominate the number of Runoff Events,*

  ➤ *mix events dominate the amount of Event Runoff*

Overview

1. **Introduce Analysis Details & Goal**

2. **Review Simulated Runoff Event Definition**

3. **Review Runoff Event Categories & Thresholds**

4. **Introduce Concept of Runoff Type**

5. **Introduce concept of a "Warning Day"**

6. **Review Assorted Histograms and Spatial Maps**

7. **Identify Inconsistent Basin Behavior & Opportunities for Improvement**

8. **Next Steps**

National Weather Service

Protecting Lives and Property
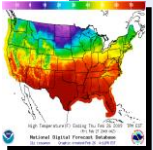
Improving Spatial Consistency

➤ **Basins initially selected for further review based on spatial inconsistency of total number of runoff events**

1. **(PDSW3) Prairie Du Sac – Wisconsin River**
2. **(SPAW3) Sparta – La Crosse Rive**
3. **(EPLW3) Big Eau Pleine River at Big Eau Pleine Reservoir**
4. **(SOSW3) Superior -- Nemadji River**
5. **(WI15C) Douglas County FFG basin**
6. **(WI14C) Bayfield County FFG basin**
7. **(WI13C) Ashland County FFG basin**
8. **(WI12C) Iron County FFG basin**
9. **(MRNM4) Marenisco – Presque Isle River**
10. **Northeastern Wisconsin – Menominee River**

Problem Basins
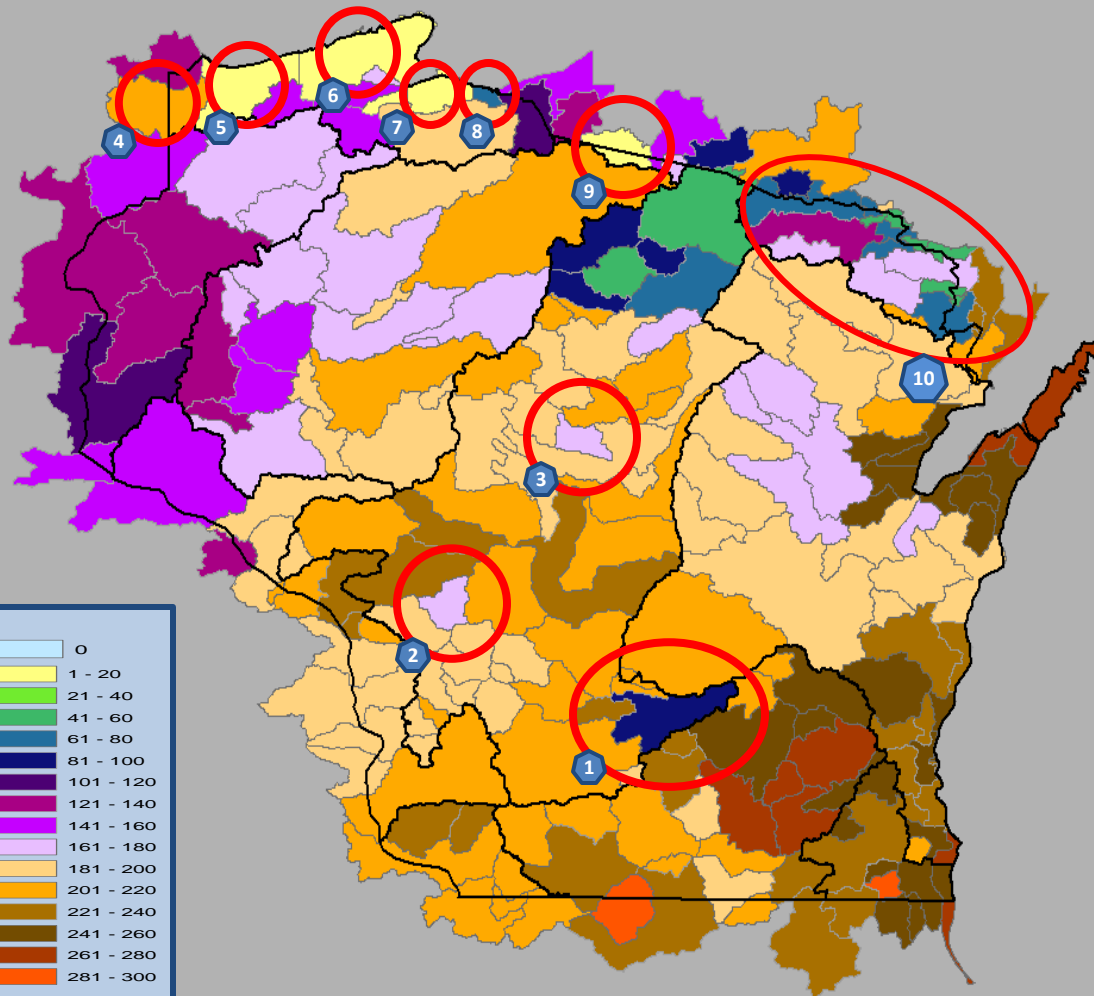
1. **PDSW3**
2. **SPAW3**
3. **EPLW3**
4. **SOSW3**
5. **WI15C**
6. **WI14C**
7. **WI13C**
8. **WI12C**
9. **MRNM4**
10. **Northeastern Wisconsin**

Investigating PDSW3

Analysis Accumulated Total Event Runoff (mm)
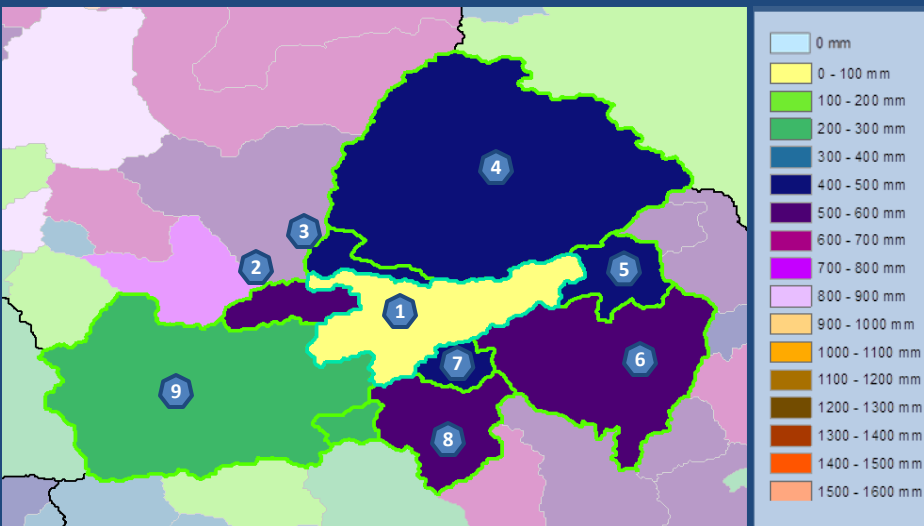
Analysis Accumulated Total Runoff Events
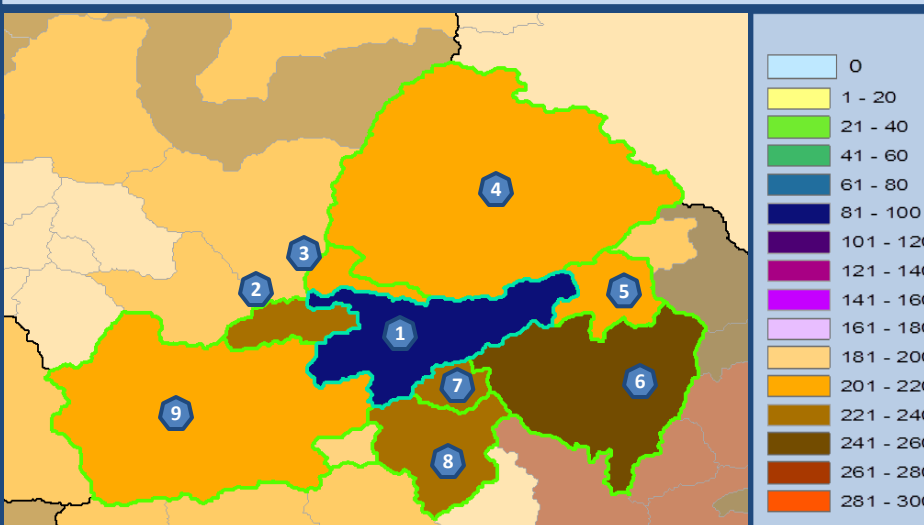
		Event Runoff	Total Events
1.	**PDSW3**	**30.4**	**89**
2.	BABW3	568	232
3.	PORW3	471	219
4.	BERW3	433	220
5.	BEAW3	486	202
6.	MILW3	506	241
7.	WDRW3	487	222
8.	MCFW3	509	228
9.	MUSW3	234	219
	Average	**462**	**223**

PDSW3 is much lower in total event runoff and events compared to the surrounding basins

Investigating PDSW3

Basin	QPF	RAIM	Total UZTWD	% Time UZTWD = 0	INTRO	% Time INTRO > 0	Event Runoff	Number Events
PDSW3	**5210**	**5648**	**222,965**	**12%**	**30.6**	**2.1%**	**30.4**	**89**
BABW3	5153	5754	185,662	12%	1217	44%	568	232
PORW3	5085	5880	194,094	12%	817	33%	471	219
BERW3	5022	5808	92,296	30%	500	18%	433	220
BEAW3	5182	5351	150,290	11%	1155	27%	486	202
MILW3	5341	5373	88,533	12%	1334	38%	506	241
WDRW3	5290	5420	117,780	12%	896	34%	487	222
MCFW3	5396	5497	116,255	14%	931	34%	509	228
MUSW3	5296	5700	140,663	12%	283	15%	234	219
Region Avg	**5221**	**5598**	**135,696**	**14%**	**892**	**30%**	**462**	**223**
% Diff from Avg	**- 0.2%**	**+ 0.9%**	**+ 64%**	**- 14%**	**- 97%**	**- 93%**	**- 93%**	**- 60%**

- ➢ **PDSW3 one of most obvious outliers in south central Wisconsin**

- ➢ **Not nearly as active as neighbor basins**

- ➢ **QPF & RAIM are similar, however UZTWD created larger deficits over the year**

- ➢ **Not generating much interflow runoff -> not very many events**

Investigating PDSW3

Customer Perspective :: Reviewing in terms of Daily Runs and Warning Days

Number Boolean Warning Day Events (All CAT)
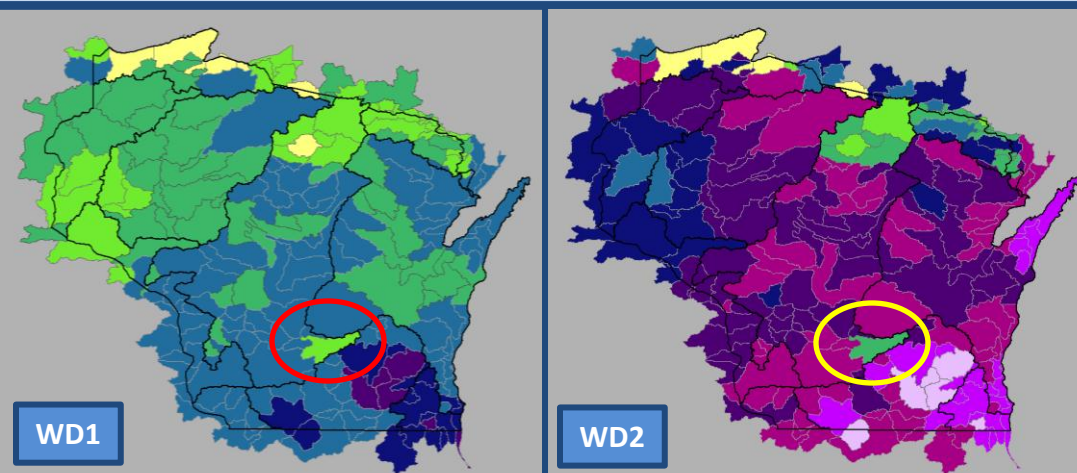
WD1

WD2
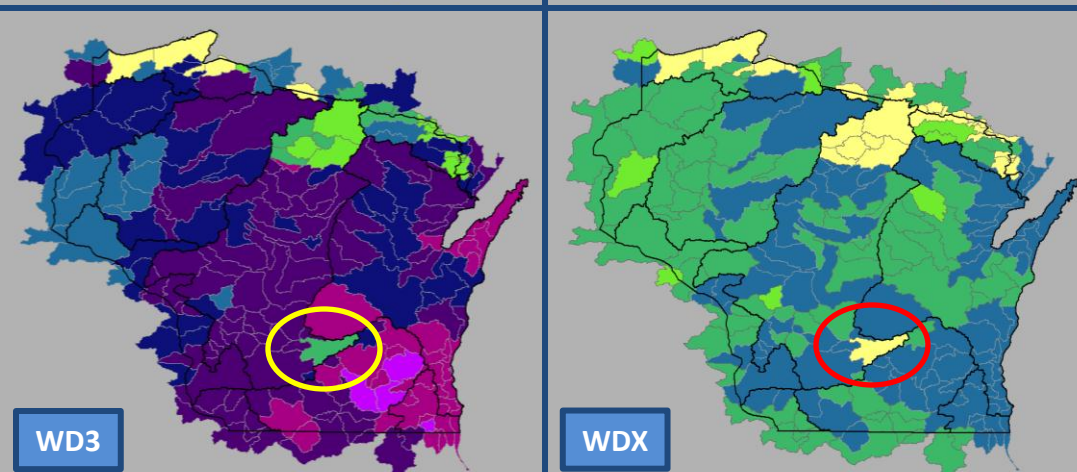
WD3

WDX

	PDSW3		Neighbor Average	
	# Events	% Runs	# Events	% Runs
Bool	75	21%	160	44%
WD1	38	10%	72	20%
WD2	57	16%	130	36%
WD3	46	13%	116	32%
WDX	15	4%	65	18%

Number Boolean Events (All CAT)

	Range
	0 - 20
	21 - 40
	41 - 60
	61 - 80
	81 - 100
	101 - 120
	121 - 140
	141 - 160
	161 - 180
	181 - 200
	201 - 220

Surface Lithology

Legend:
- Carbonate Residual Material
- Non-Carbonate Residual Material
- Alkaline Intrusive Volcanic Rock
- Silicic Residual Material
- Extrusive Volcanic Rock
- Colluvial Sediment
- Glacial Till, Clayey
- Glacial Till, Loamy
- Glacial Till, Coarse-Textured
- Glacial Outwash and Glacial Lake Sediment, Coarse-Textured
- Glacial Lake Sediment, Fine-Textured
- Hydric, Peat and Muck
- Eolian Sediment, Coarse-Textured (Sand Dunes)
- Eolian Sediment, Fine-Textured (Glacial Loess)
- Saline Lake Sediment
- Alluvium and Fine-Textured Coastal Zone Sediment
- Coastal Zone Sediment, Coarse-Textured
- Water

NLCD 2006 Land Cover

Legend:
- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Consolidated Shore
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grasslands/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Land Surface Forms

Legend:
- Flat Plains
- Smooth Plains
- Irregular Plains
- Escarpments
- Low Hills
- Hills
- Breaks/Foothills
- Low Mountains
- High Mountains/Deep Canyons
- Drainage Channels

Investigating PDSW3

➤ **Review of regional surface characteristics suggests PDSW3 should be similar in basin response with its neighbors**

➤ **NCRFC SAC-SMA parameters for PDSW3 are spatially inconsistent with neighbors**

➤ **ACTION ::**
  - ➤ *NCRFC SAC-SMA parameters could be adjusted to line up with neighbor values to ensure similar results for MMAS Runoff Risk Advisory Tool and remain accurate for streamflow forecasting*

Investigating SPAW3

Analysis Accumulated Total Event Runoff (mm)

	0 - 100 mm
	100 - 200 mm
	200 - 300 mm
	300 - 400 mm
	400 - 500 mm
	500 - 600 mm
	600 - 700 mm
	700 - 800 mm
	800 - 900 mm
	900 - 1000 mm
	1000 - 1100 mm
	1100 - 1200 mm
	1200 - 1300 mm
	1300 - 1400 mm
	1400 - 1500 mm
	1500 - 1600 mm

Analysis Accumulated Total Runoff Events

	0
	1 - 20
	21 - 40
	41 - 60
	61 - 80
	81 - 100
	101 - 120
	121 - 140
	141 - 160
	161 - 180
	181 - 200
	201 - 220
	221 - 240
	241 - 260
	261 - 280
	281 - 300
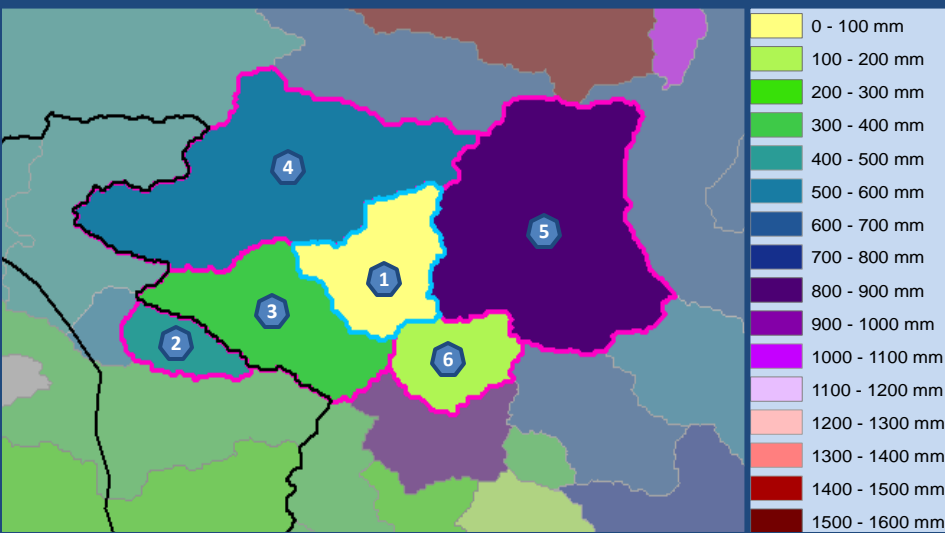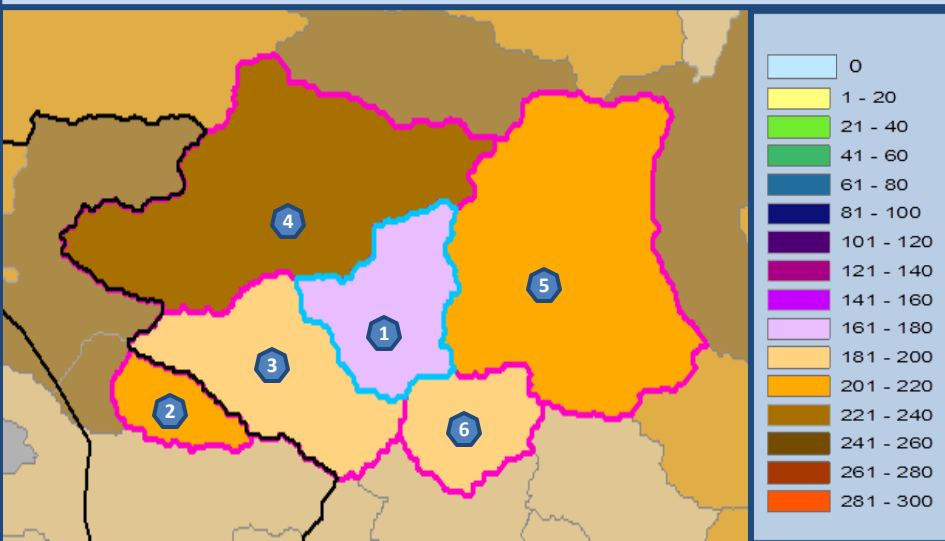
		Event Runoff	Total Events
1.	SPAW3	70	161
2.	LCRW3	406	208
3.	WSAW3	315	198
4.	GALW3	523	235
5.	NLSW3	866	203
6.	ONTW3	190	188
	Average	460	206

SPAW3 is not producing as much interflow runoff and thus event runoff. This leads to fewer runoff events over the analysis time frame.

Investigating SPAW3

Basin	QPF	RAIM	Total UZTWD	% Time UZTWD = 0	INTRO	% Time INTRO > 0	Event Runoff	Number Events
SPAW3	**4786**	**5265**	**133,978**	**24%**	**71**	**5%**	**70**	**161**
LCRW3	4763	5156	152,262	24%	640	26%	406	208
WSAW3	4784	5160	159,480	12%	448	20%	315	198
GALW3	4696	5341	111,882	14%	766	25%	523	235
NLSW3	4800	5628	128,804	26%	1127	23%	866	203
ONTW3	4880	5367	115,124	15%	216	12%	190	188
Region Avg	4785	5330	133,510	18%	639	21%	460	206
% Diff from Avg	0.03%	- 1.2%	0.35%	+ 32%	- 89%	- 76%	- 85%	- 22%

➢ **SPAW3 is a more subtle outlier where it produces about 22% less events than neighbors**

➢ **Forcings and UZTWD behavior are spatially consistent**

➢ **Again this basin does not produce as much interflow runoff as neighbors (89% less)**

➢ **When Interflow is generated an event is usually identified**

Investigating SPAW3

Customer Perspective :: Reviewing in terms of Daily Runs and Warning Days

Number Boolean Warning Day Events (All CAT)
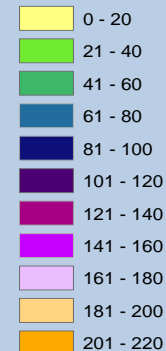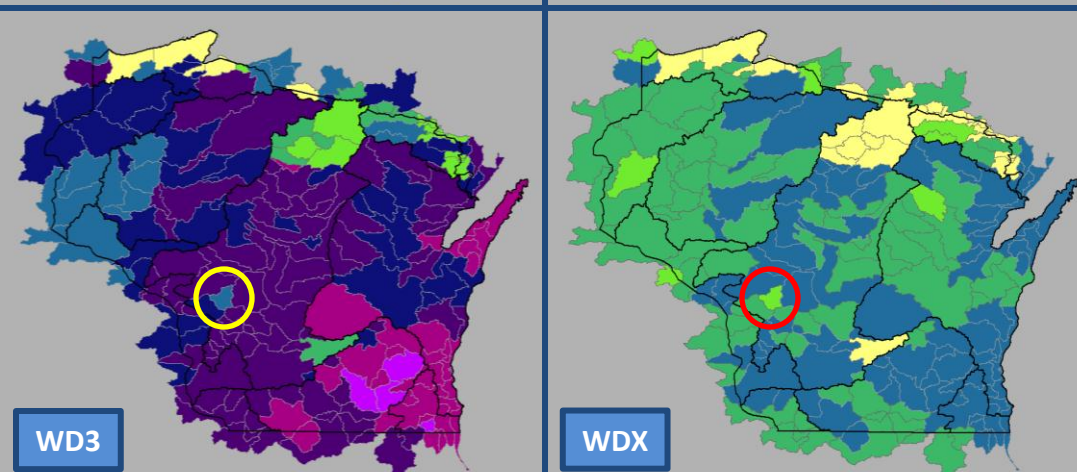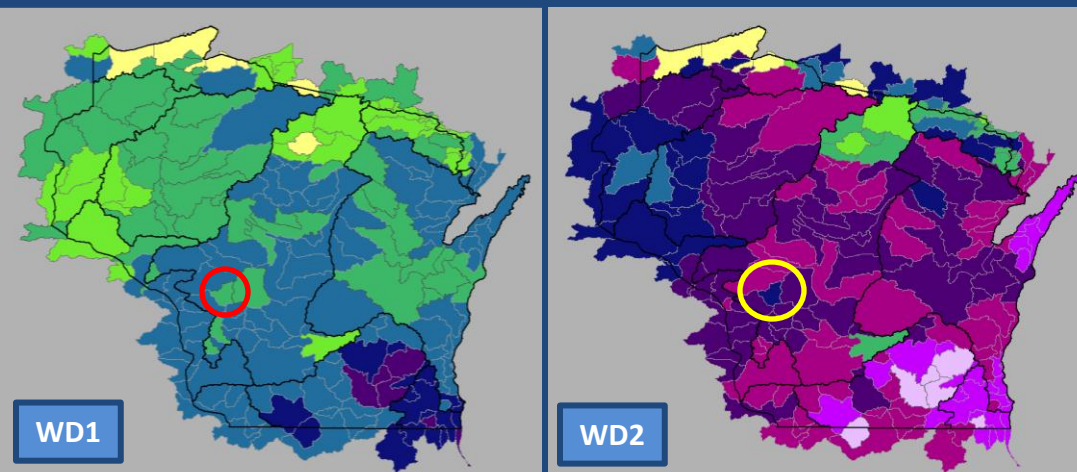
	SPAW3		Neighbor Average	
	# Events	% Runs	# Events	% Runs
Bool	126	35%	156	43%
WD1	51	14%	66	18%
WD2	91	25%	118	32%
WD3	78	21%	108	29%
WDX	38	10%	59	16%

Number Boolean Events (All CAT)

Legend:
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 220

Surface Lithology

- Carbonate Residual Material
- Non-Carbonate Residual Material
- Alkaline Intrusive Volcanic Rock
- Silicic Residual Material
- Extrusive Volcanic Rock
- Colluvial Sediment
- Glacial Till, Clayey
- Glacial Till, Loamy
- Glacial Till, Coarse-Textured
- Glacial Outwash and Glacial Lake Sediment, Coarse-Textured
- Glacial Lake Sediment, Fine-Textured
- Hydric, Peat and Muck
- Eolian Sediment, Coarse-Textured (Sand Dunes)
- Eolian Sediment, Fine-Textured (Glacial Loess)
- Saline Lake Sediment
- Alluvium and Fine-Textured Coastal Zone Sediment
- Coastal Zone Sediment, Coarse-Textured
- Water

NLCD 2006 Land Cover

- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Consolidated Shore
- Deciduous Forest
- Evergeen Forest
- Mixed Forest
- Shrub/Scrub
- Grasslands/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaccous Wetlands

Land Surface Forms

- Flat Plains
- Smooth Plains
- Irregular Plains
- Escarpments
- Low Hills
- Hills
- Breaks/Foothills
- Low Mountains
- High Mountains/Deep Canyons
- Drainage Channels

Investigating SPAW3

➢ **Although there is slight areal variation in land cover and topography in the region, surface lithology is consistent with most neighbors.**

➢ **NCRFC SAC-SMA parameters for SPAW3 are fairly consistent with neighbors**

➢ **ACTION ::**
  ➢ *Slight adjustment to NCRFC SAC-SMA parameters could be done to produce more interflow runoff similar to neighbors*

Investigating EPLW3

Analysis Accumulated Total Event Runoff (mm)

Legend:
- 0 - 100 mm
- 100 - 200 mm
- 200 - 300 mm
- 300 - 400 mm
- 400 - 500 mm
- 500 - 600 mm
- 600 - 700 mm
- 700 - 800 mm
- 800 - 900 mm
- 900 - 1000 mm
- 1000 - 1100 mm
- 1100 - 1200 mm
- 1200 - 1300 mm
- 1300 - 1400 mm
- 1400 - 1500 mm
- 1500 - 1600 mm

Analysis Accumulated Total Runoff Events

Legend:
- 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 220
- 221 - 240
- 241 - 260
- 261 - 280
- 281 - 300
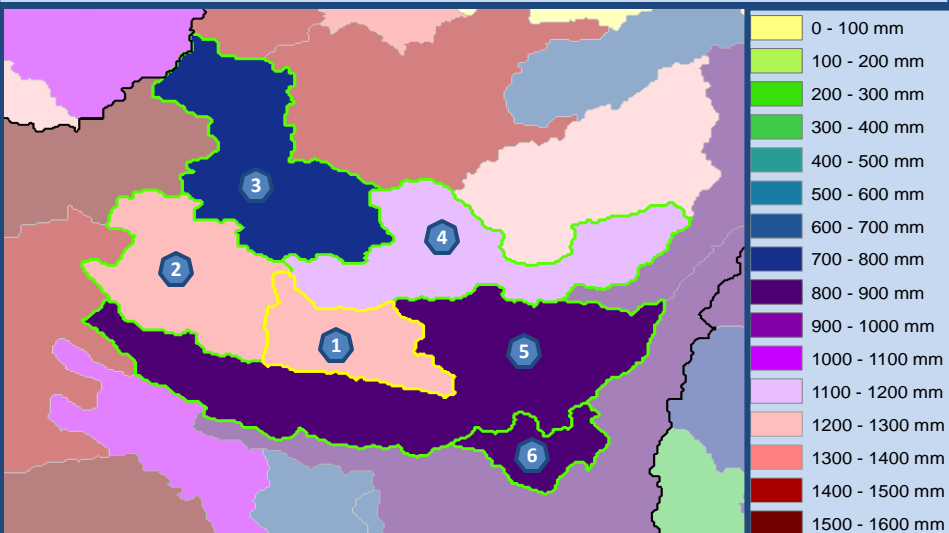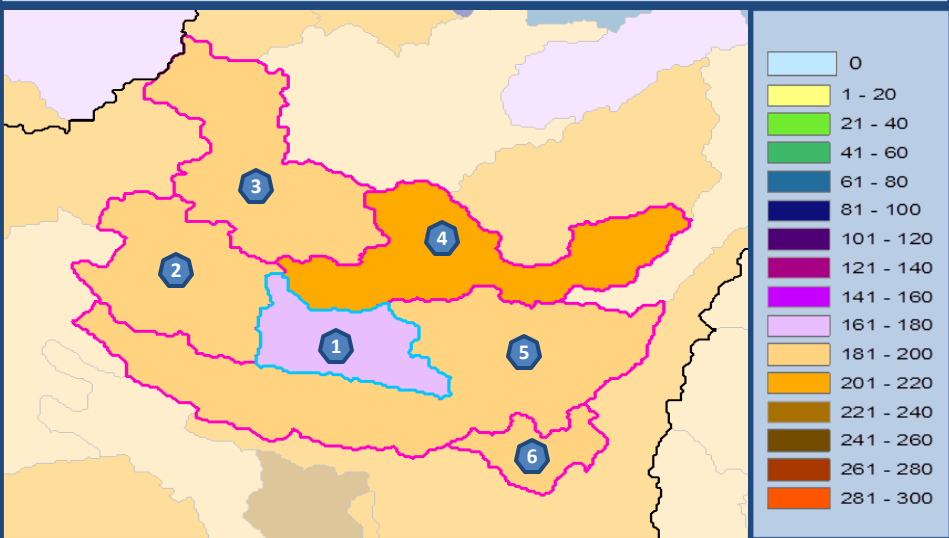
		Event Runoff	Total Events
1.	EPLW3	1290	176
2.	STRW3	1279	189
3.	RIBW3	800	196
4.	ROTW3	1121	204
5.	DUBW3	896	197
6.	STPW3	838	196
	Average	987	196

EPLW3 produces the most event runoff in its region, however produces 10% less events compared to it neighbors.

Investigating EPLW3

Basin	QPF	RAIM	Total UZTWD	% Time UZTWD = 0	INTRO	% Time INTRO > 0	Event Runoff	Number Events
EPLW3	**4554**	**5108**	**133,686**	**29%**	**1669**	**29%**	**1290**	**176**
STRW3	4495	5046	131,580	33%	1664	26%	1279	189
RIBW3	4474	4941	115,074	39%	1369	40%	800	196
ROTW3	4535	5056	99,450	33%	1566	35%	1121	204
DUBW3	4593	5360	133,668	19%	1254	29%	896	197
STPW3	4636	5264	140,803	20%	1226	29%	838	196
Region Avg	**4547**	**5133**	**124,115**	**29%**	**1416**	**32%**	**987**	**196**
% Diff from Avg	**+ 0.2%**	**- 0.5%**	**+ 7.7%**	**0%**	**+ 18%**	**- 9%**	**+ 31%**	**- 10%**

- ➢ **EPLW3 is another subtle outlier where it produces about 10% less events than neighbors**

- ➢ **Forcings and UZTWD behavior are spatially consistent**

- ➢ **This basin actually produces more interflow runoff than its neighbors (+ 18%)**

Investigating EPLW3

Customer Perspective :: Reviewing in terms of Daily Runs and Warning Days

Number Boolean Warning Day Events (All CAT)
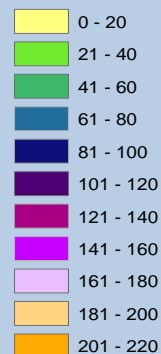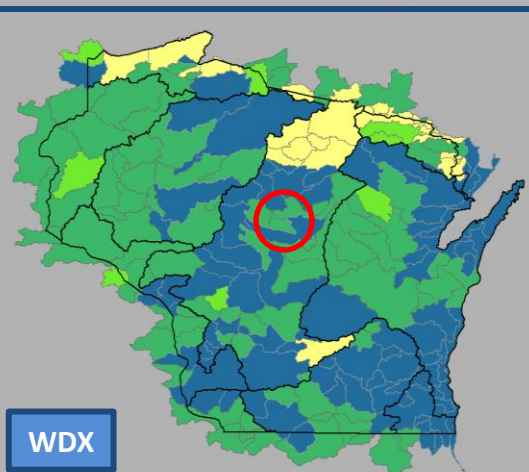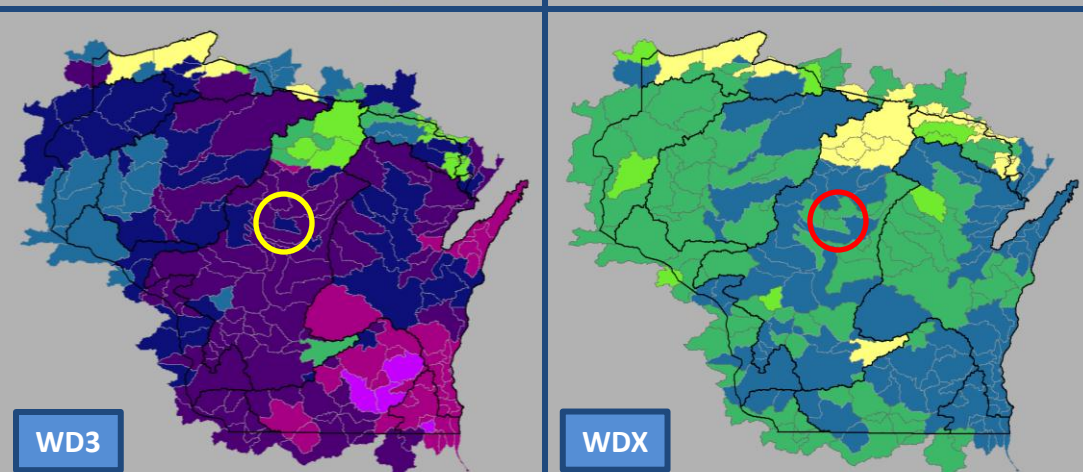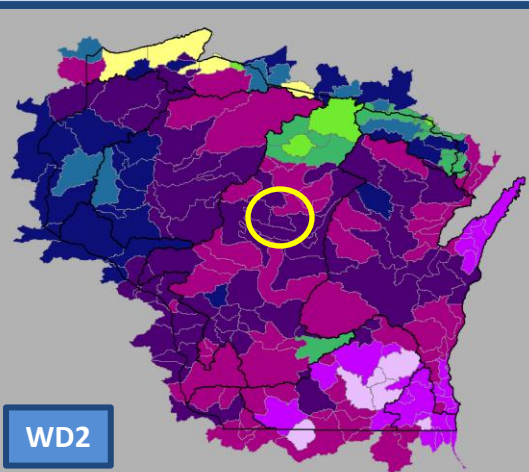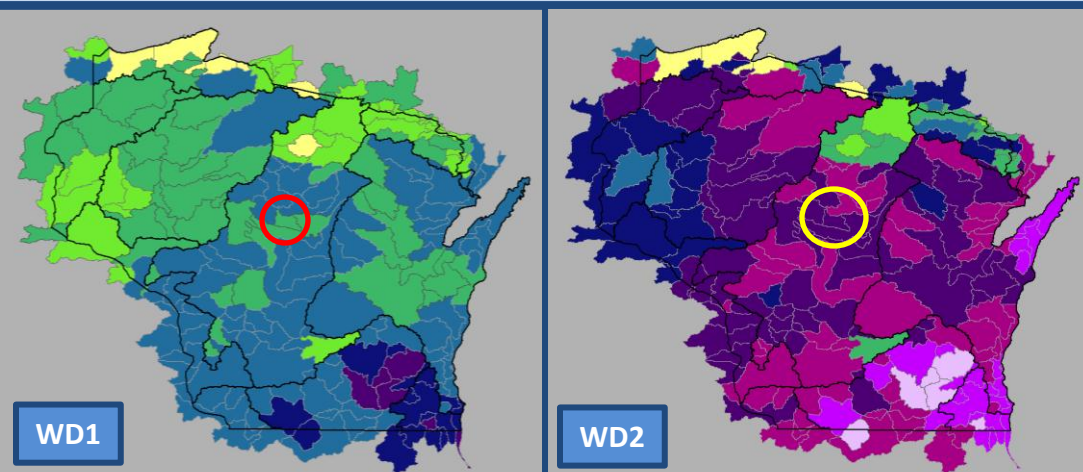
	EPLW3		Neighbor Average	
	# Events	% Runs	# Events	% Runs
Bool	**141**	**39%**	150	41%
WD1	**52**	**14%**	64	17%
WD2	**112**	**31%**	118	32%
WD3	**100**	**27%**	104	29%
WDX	**55**	**15%**	60	17%

Number Boolean Events (All CAT)

Legend:
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 220

Surface Lithology

Legend
Carbonate Residual Material
Non-Carbonate Residual Material
Alkaline Intrusive Volcanic Rock
Silicic Residual Material
Extrusive Volcanic Rock
Colluvial Sediment
Glacial Till, Clayey
Glacial Till, Loamy
Glacial Till, Coarse-Textured
Glacial Outwash and Glacial Lake Sediment, Coarse-Textured
Glacial Lake Sediment, Fine-Textured
Hydric, Peat and Muck
Eolian Sediment, Coarse-Textured (Sand Dunes)
Eolian Sediment, Fine-Textured (Glacial Loess)
Saline Lake Sediment
Alluvium and Fine-Textured Coastal Zone Sediment
Coastal Zone Sediment, Coarse-Textured
Water

NLCD 2006 Land Cover

Legend
Open Water
Perennial Ice/Snow
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Consolidated Shore
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Grasslands/Herbaceous
Pasture/Hay
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands

Land Surface Forms

Legend
Flat Plains
Smooth Plains
Irregular Plains
Escarpments
Low Hills
Hills
Breaks/Foothills
Low Mountains
High Mountains/Deep Canyons
Drainage Channels

Investigating EPLW3

➢ **Regional review of surface characteristics suggests EPLW3 should behave similar to neighbors**

➢ **NCRFC SAC-SMA parameters for EPLW3 are spatially consistent and exactly the same as STRW3 to its west**

➢ **ACTION ::**

    ➢ *Overall EPLW3 behaves very similar to neighbor basins in terms of amount and timing of interflow runoff as well as UZTWD behavior.*

    ➢ *The basin threshold does not apply here. Its not a problem of too few CAT3 runoff events, just runoff events in general.*

    ➢ *Very similar basin parameters and forcing data yet less simulated events suggest the small difference could be due to starting basin conditions and precip variability over the year.*

    ➢ *No changes to this basin are suggested*
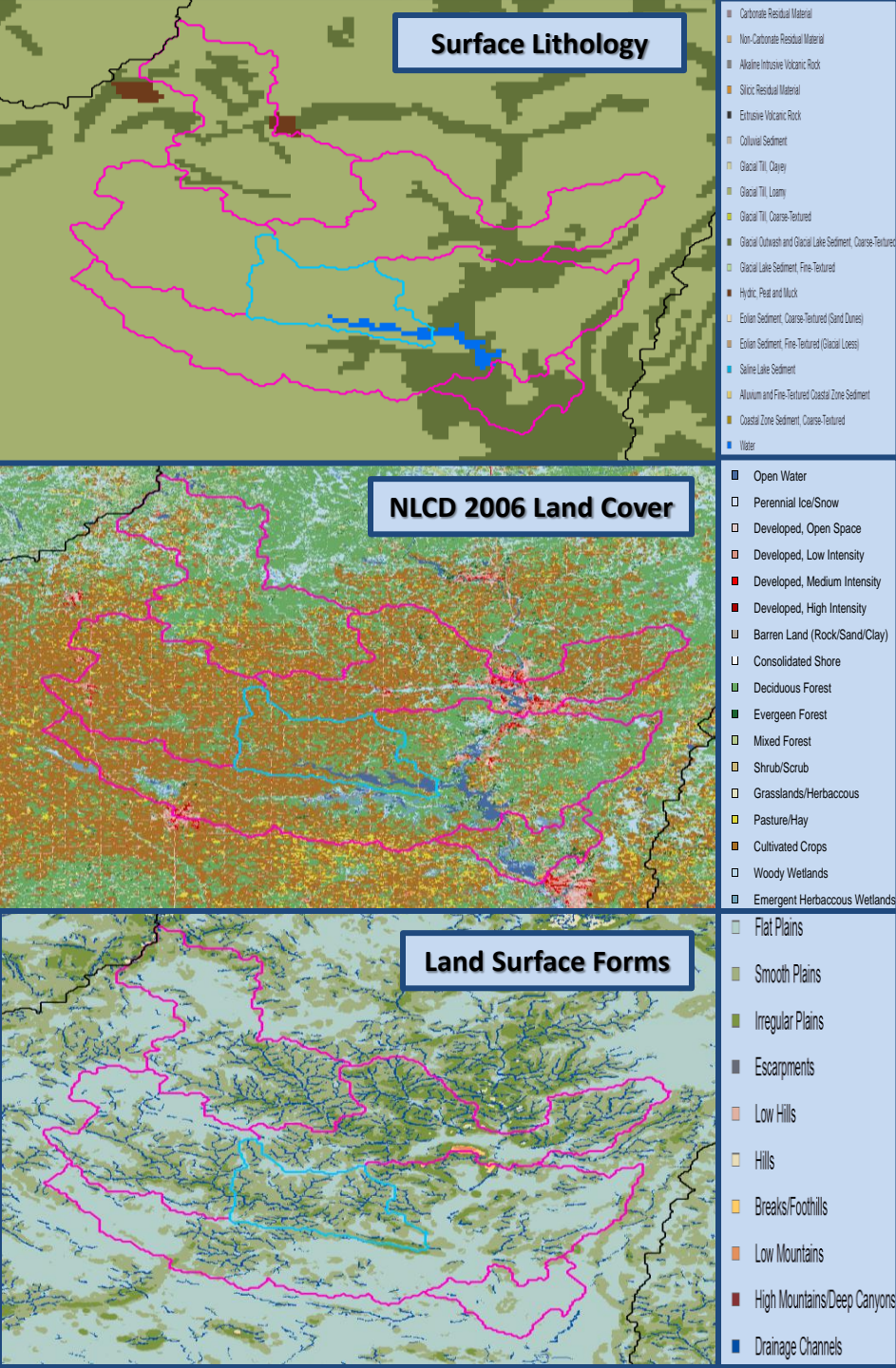
Investigating Northwestern Wisconsin Basins

Analysis Accumulated Total Event Runoff (mm)
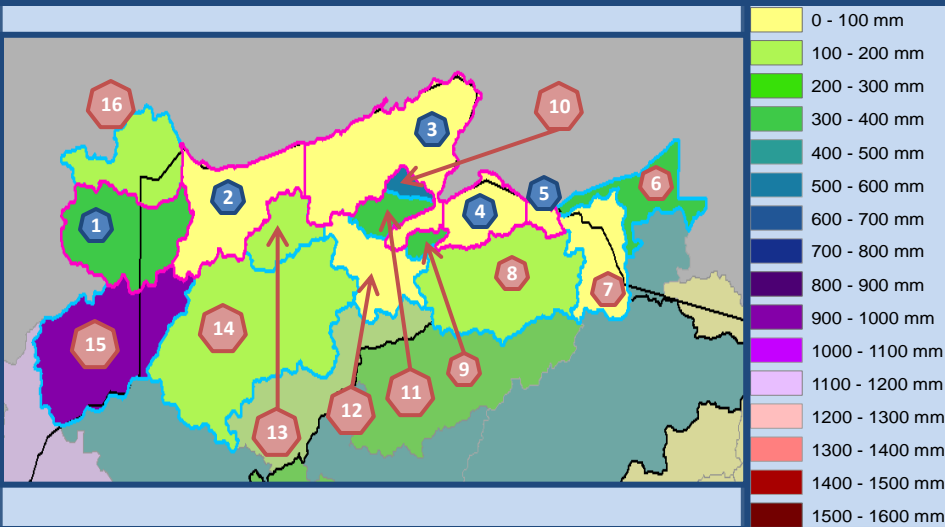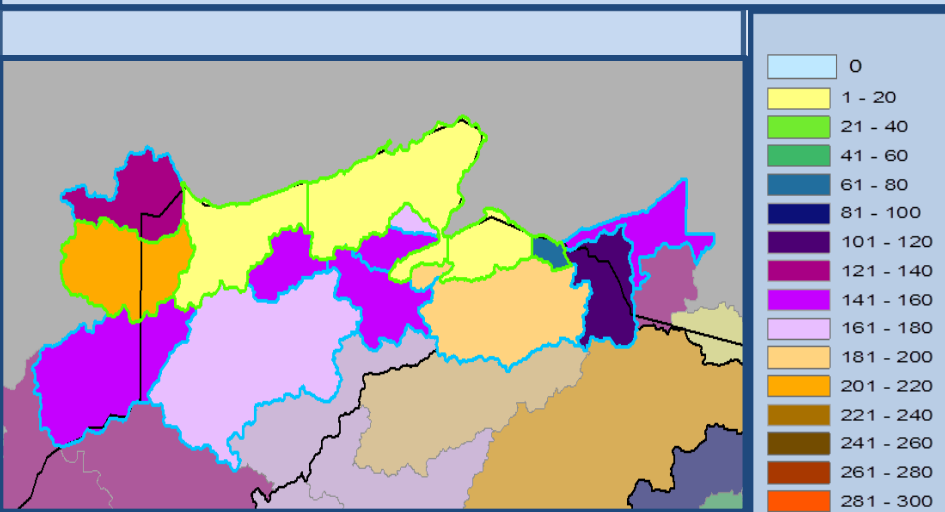
		Event Runoff	Total Events
1.	SOSW3	365	210
2.	WI15C	0.63	9
3.	WI14C	0.97	12
4.	WI13C	0.90	10
5.	WI12C	18.6	62
6.	MI46C	390	153
7.	MRSW3	68	105
8.	ODAW3	144	192
9.	WHRW3	307	195
10.	WTLW3	588	171
11.	MOQW3	310	158
12.	MASW3	97	146
13.	BRSW3	197	150
14.	DANW3	156	170
15.	GTBM5	955	156
16.	SLSW3	166	127
Average		307	157

Analysis Accumulated Total Runoff Events

Investigating Northwestern Wisconsin Basins

Basin	QPF	% Diff from Avg	RAIM	% Diff from Avg	Total UZTWD	% Diff from Avg	% Time UZTWD = 0	% Diff from Avg	INTRO	% Diff from Avg	% Time INTRO > 0	% Diff from Avg	Event Runoff	% Diff from Avg	Number Events	% Diff from Avg
SOSW3	4001	- 4%	4637	- 2%	77,307	- 38%	28%	- 13%	554	+ 35%	37%	+ 90%	365	+ 19%	210	+ 34%
WI15C	4049	- 3%	4193	- 12%	163,726	+ 30%	6%	- 81%	0.63	- 99%	0.06%	- 99%	0.63	- 99%	9	- 94%
WI14C	4106	- 1%	4279	- 10%	146,101	+ 16%	7%	- 78%	0.97	- 99%	0.12	- 99%	0.97	- 99%	12	- 92%
WI13C	4220	+ 1%	4161	- 12%	149,353	+ 19%	6%	- 81%	0.90	- 99%	0.12	- 99%	0.90	- 99%	10	- 93%
WI12C	4264	+ 2%	4540	- 4%	143,266	+ 14%	7%	- 78%	18.9	- 95%	2.4	- 88%	18.6	- 94%	62	- 60%
MI46C	4357		4435		77,331		16%		416		10%		390		153	
MRSW3	4354		4952		150,330		30%		77		10%		68		105	
ODAW3	4289		4791		101,757		29%		200		17%		144		192	
WHRW3	4185		4470		102,635		29%		450		21%		307		195	
WTLW3	4115		5334		155,571		39%		684		36%		588		171	
MOQW3	4137		4454		146,972		36%		415		28%		310		158	
MASW3	4166		4854		99,478		40%		117		19%		97		146	
BRSW3	4082		5256		155,745		34%		265		16%		197		150	
DANW3	4128		4677		93,386		39%		161		10%		156		170	
GTBM5	4048		4708		108,073		34%		1501		35%		955		156	
SLSW3	3972		4307		189,396		28%		216		12%		166		127	
Region Avg	4167		4749		125,516		32%		409		19%		307		157	

Investigating Northwestern Wisconsin Basins

➢ **SOSW3 is more active than its neighbors**

  ➢ *It produces 19% more event runoff than the regional average*

  ➢ *It is producing 34% more events*

  ➢ *This basin is not building as much accumulated UZTWD as region*

  ➢ *It produces 35% more interflow runoff than regional average*

  ➢ *It produces interflow runoff 90% more often than regional average*

➢ **The 4 Wisconsin Flash Flood Guidance Basins (WI15C, WI14C, WI13C, WI12C)**

  ➢ *These basins generate higher UZTW deficits than regional average*

  ➢ *They rarely have conditions where UZTWD = 0*

  ➢ *They produce very little interflow runoff*

Investigating Northwestern Wisconsin Basins

Customer Perspective : Reviewing in terms of Warning Days

Number Boolean Warning Day Events (All CAT)

WD1

WD2

WD3

WDX

Legend:
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 220
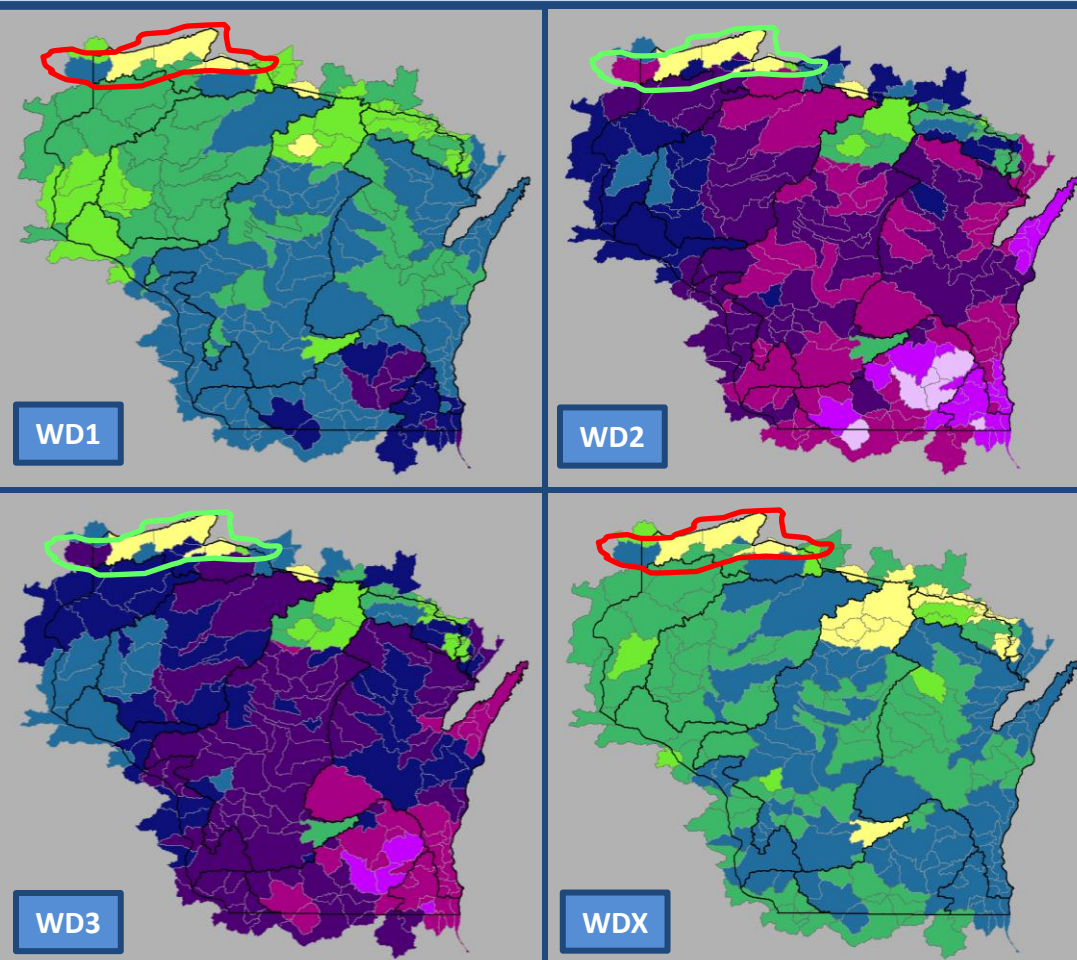
	WD1	WD2	WD3	WDX
SOSW3 Num Events	61	131	113	68
SOSW3 % Runs	17%	36%	31%	19%
WI15C Num Events	7	8	6	0
WI15C % Runs	2%	2%	2%	0%
WI14C Num Events	7	7	5	0
WI14C % Runs	2%	2%	1%	0%
WI13C Num Events	7	8	5	0
WI13C % Runs	2%	2%	1%	0%
WI12C Num Events	16	32	27	17
WI12C % Runs	4%	9%	7%	5%
Average Num Events	47	97	84	50
Average % Runs	13%	35%	23%	14%

Investigating Northwestern Wisconsin Basins

Surface Lithology

NLCD 2006 Land Cover

Land Surface Forms

Legend (Surface Lithology):
- Carbonate Residual Material
- Non-Carbonate Residual Material
- Alkaline Intrusive Volcanic Rock
- Silicic Residual Material
- Extrusive Volcanic Rock
- Colluvial Sediment
- Glacial Till, Clayey
- Glacial Till, Loamy
- Glacial Till, Coarse-Textured
- Glacial Outwash and Glacial Lake Sediment, Coarse-Textured
- Glacial Lake Sediment, Fine-Textured
- Hydric, Peat and Muck
- Eolian Sediment, Coarse-Textured (Sand Dunes)
- Eolian Sediment, Fine-Textured (Glacial Loess)
- Saline Lake Sediment
- Alluvium and Fine-Textured Coastal Zone Sediment
- Coastal Zone Sediment, Coarse-Textured
- Water

Legend (NLCD 2006 Land Cover):
- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Consolidated Shore
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grasslands/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Legend (Land Surface Forms):
- Flat Plains
- Smooth Plains
- Irregular Plains
- Escarpments
- Low Hills
- Hills
- Breaks/Foothills
- Low Mountains
- High Mountains/Deep Canyons
- Drainage Channels

➢ **Regional review of surface characteristics indicates there is some heterogeneity among the 16 basins examined**

➢ **However SOSW3 should behave similar to nearby basins GTBM5 & SLSW3**

➢ **Differences in the WI FFG basins should not be as extreme as the analysis indicates**

➢ **ACTION ::**

  ➢ *SOSW3 – Look closer at SAC-SMA parameters for this basin. Some minor differences were seen with neighbor basins. Altering the parameters could throttle down on the event simulations for this basin and blend in with regional average.*

  ➢ *The WI FFG basins (WI15C, WI14C, WI13C, and WI12C) were given regionalized SAC-SMA parameters at the start and are not evaluated daily. Streamflow is not simulated for these locations as they drain into the lake.*

  ➢ *These basins can be given new parameters to blend them into the regional average for runoff events*

Investigating MRNM4

Analysis Accumulated Total Event Runoff (mm)

Legend:
- 0 - 100 mm
- 100 - 200 mm
- 200 - 300 mm
- 300 - 400 mm
- 400 - 500 mm
- 500 - 600 mm
- 600 - 700 mm
- 700 - 800 mm
- 800 - 900 mm
- 900 - 1000 mm
- 1000 - 1100 mm
- 1100 - 1200 mm
- 1200 - 1300 mm
- 1300 - 1400 mm
- 1400 - 1500 mm
- 1500 - 1600 mm
- 1600 - 1700 mm
- 1700 - 1800 mm
- 1800 - 1900 mm
- 1900 - 2000 mm
- 2000 - 2100 mm
- 2100 - 2000 mm

Analysis Accumulated Total Runoff Events

Legend:
- 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 220
- 221 - 240
- 241 - 260
- 261 - 280
- 281 - 300
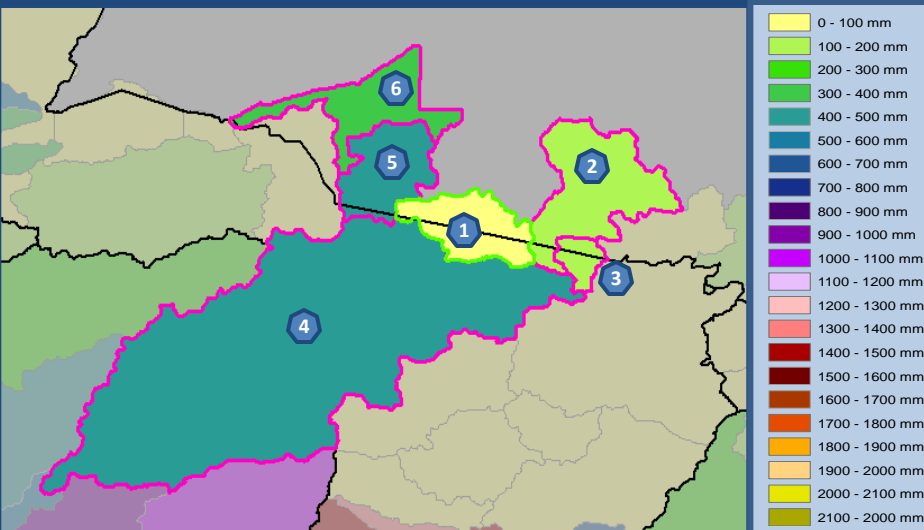
		Event Runoff	Total Events
1.	MRNM4	1.8	14
2.	EWNM4	172	151
3.	ORCM4	156	179
4.	BGFW3	443	204
5.	BESM4	437	140
6.	MI46C	390	153
	Average	**320**	**165**
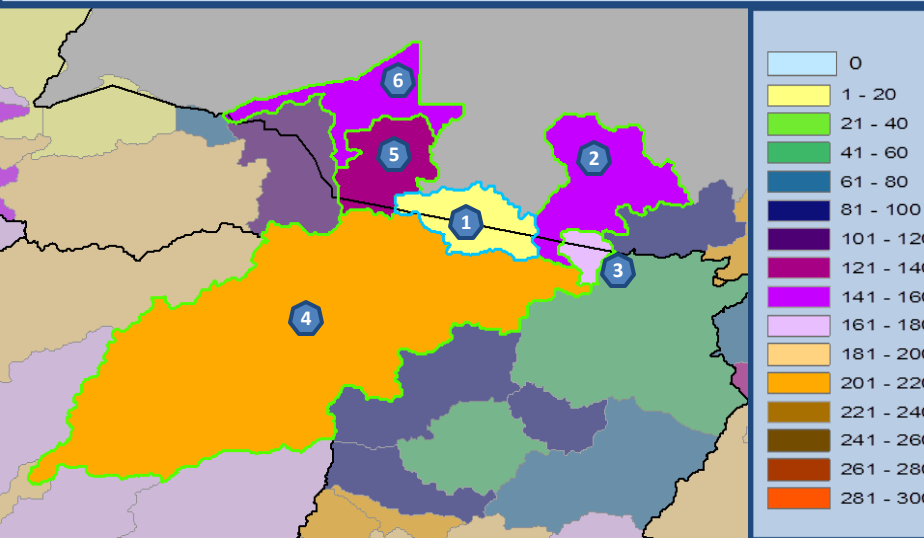
MRNM4 has only a few runoff events and produces very little event runoff

Investigating MRNM4

Basin	QPF	RAIM	Total UZTWD	% Time UZTWD = 0	INTRO	% Time INTRO > 0	Event Runoff	Number Events
MRNM4	4379	4349	186,865	41%	1.77	0.1%	1.77	14
EWNM4	4396	4423	78,384	30%	176	8%	172	151
ORCM4	4342	4251	83,506	29%	159	8%	156	179
BGFW3	4369	5065	95,344	39%	521	20%	443	204
BESM4	4367	4835	60,078	35%	460	10%	437	140
MI46C	4357	4435	77,331	16%	416	10%	390	153
Region Avg	4366	4602	78,929	30%	346	11%	320	165
% Diff from Avg	+ 0.3%	- 5.5%	+ 137%	+ 38%	- 99%	- 99%	- 99%	- 92%

➢ **MRNM4 is much different in terms of interflow and runoff events**

➢ **QPF & RAIM are similar, however UZTWD created larger deficits over the year**

➢ **Not generating much interflow runoff -> not very many events**
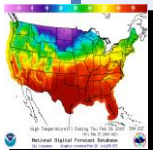
Investigating MRNM4

Customer Perspective :: Reviewing in terms of Daily Runs and Warning Days

Number Boolean Warning Day Events (All CAT)

WD1

WD2

WD3

WDX
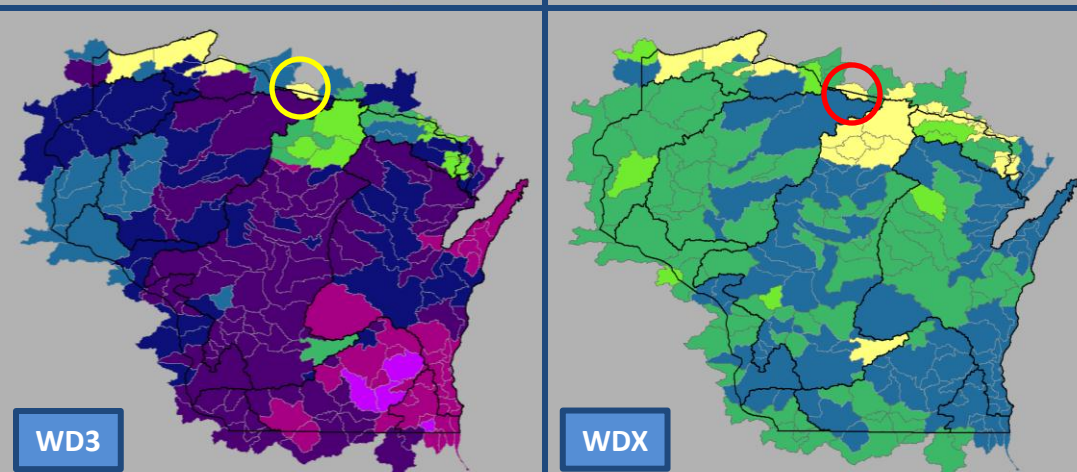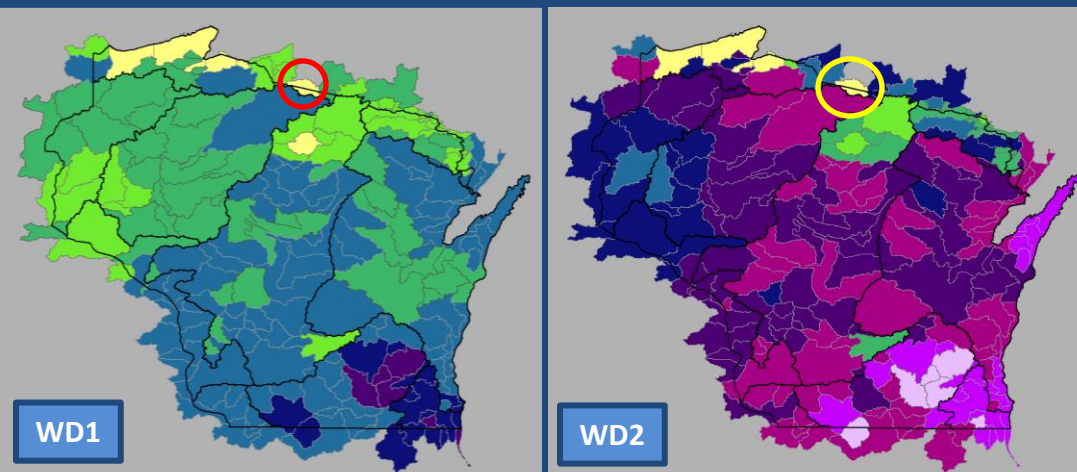
	MRNM4		Neighbor Average	
	# Events	% Runs	# Events	% Runs
Bool	13	4%	125	34%
WD1	7	2%	47	13%
WD2	11	3%	93	26%
WD3	6	2%	81	22%
WDX	0	0%	52	14%

Number Boolean Events (All CAT)

0 - 20	
21 - 40	
41 - 60	
61 - 80	
81 - 100	
101 - 120	
121 - 140	
141 - 160	
161 - 180	
181 - 200	
201 - 220	
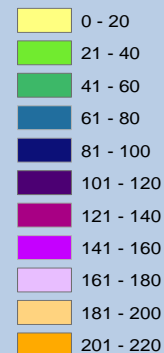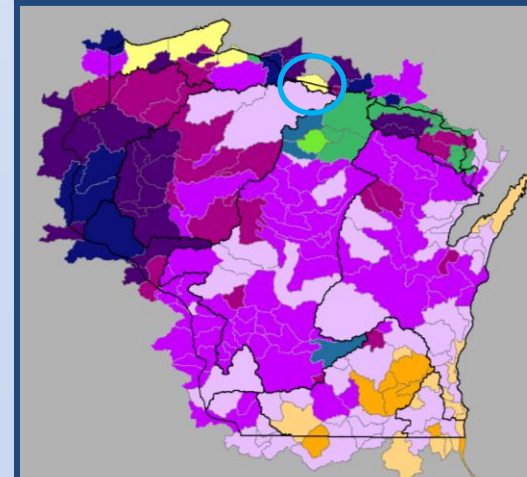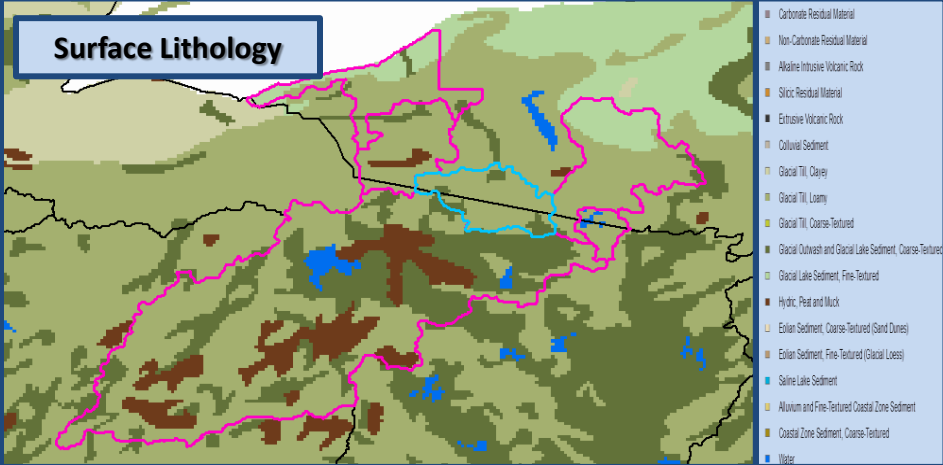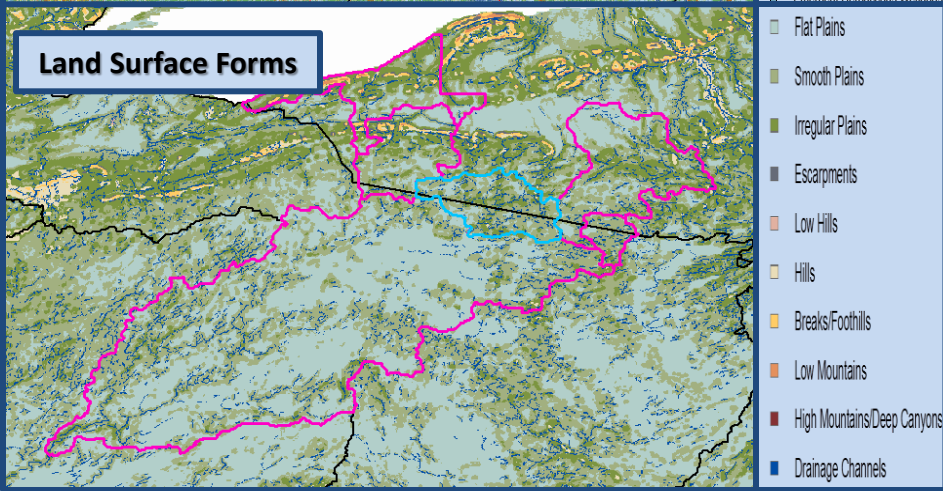
Investigating MRNM4

- Regional review of surface characteristics suggests MRNM4 should behave similar to neighbors

- NCRFC SAC-SMA parameters for MRNM4 differ from nearby basins. This basin moves water to the lower zones and then to base flow instead of generating interflow runoff

- ACTION ::
  - *MRNM4 is not calibrated to produce interflow runoff*

  - *Therefore this basin does not produce runoff events and sticks out dramatically compared to its neighbors*

  - *Its suggested that this basin be recalibrated to align with its neighbor basins if possible*

Surface Lithology

- Carbonate Residual Material
- Non-Carbonate Residual Material
- Alkaline Intrusive Volcanic Rock
- Silicic Residual Material
- Extrusive Volcanic Rock
- Colluvial Sediment
- Glacial Till, Clayey
- Glacial Till, Loamy
- Glacial Till, Coarse-Textured
- Glacial Outwash and Glacial Lake Sediment, Coarse-Textured
- Glacial Lake Sediment, Fine-Textured
- Hydric, Peat and Muck
- Eolian Sediment, Coarse-Textured (Sand Dunes)
- Eolian Sediment, Fine-Textured (Glacial Loess)
- Saline Lake Sediment
- Alluvium and Fine-Textured Coastal Zone Sediment
- Coastal Zone Sediment, Coarse-Textured
- Water

NLCD 2006 Land Cover

- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Consolidated Shore
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grasslands/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Land Surface Forms

- Flat Plains
- Smooth Plains
- Irregular Plains
- Escarpments
- Low Hills
- Hills
- Breaks/Foothills
- Low Mountains
- High Mountains/Deep Canyons
- Drainage Channels

Investigating Northeastern Wisconsin

Analysis Accumulated Total Event Runoff (mm)

	0 - 25 mm
	25 - 50 mm
	50 - 75 mm
	75 - 100 mm
	100 - 125 mm
	125 - 150 mm
	150 - 175 mm
	175 - 200 mm
	200 - 225 mm
	225 - 250 mm
	250 - 275 mm

Analysis Accumulated Total Runoff Events

	45 - 50
	51 - 75
	76 - 100
	101 - 125
	126 - 150
	151 - 175
	176 - 200
	201 - 225
	226 - 250
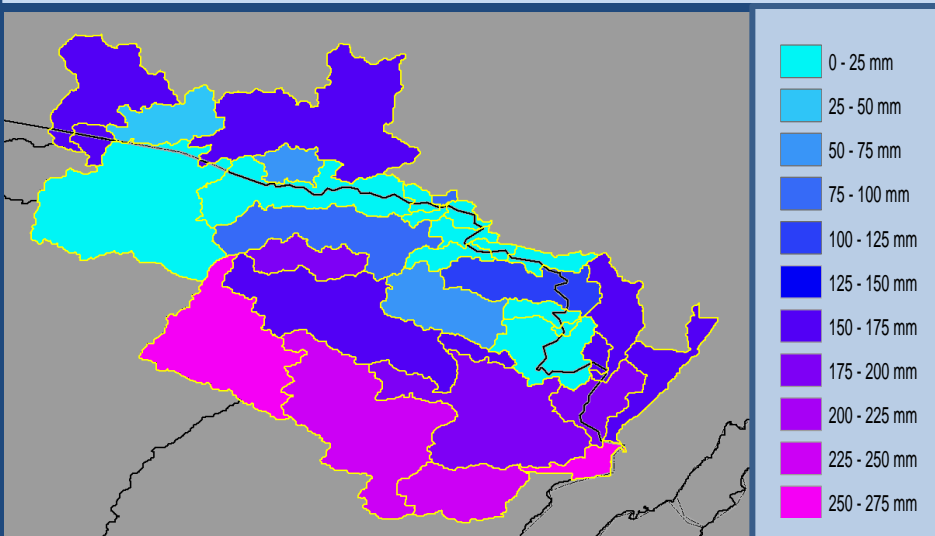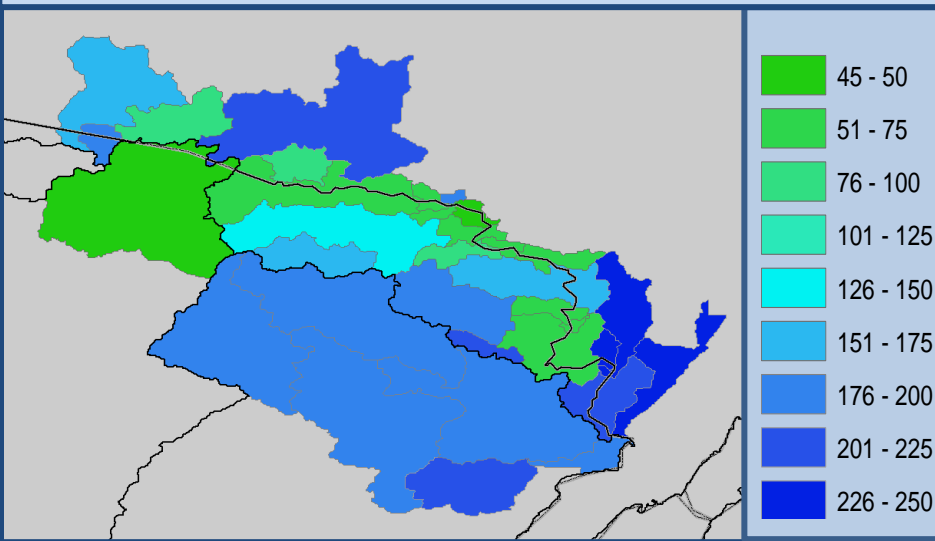
- ➤ **The watersheds in Northeastern Wisconsin show some discontinuity in generating interflow runoff, and thus also runoff events**

- ➤ **Total Event Runoff for the area highlighted ranged from 6mm to 266mm for the analysis period**

- ➤ **Total Runoff Events ranged from 45 to 232 analysis accumulated events**

- ➤ **Concern here is the greater number of basins that are spatially discontinuous in behavior.**

- ➤ **Its not just one basin that can be analyzed or modified if needed**

Investigating Northeastern Wisconsin

Customer Perspective :: Reviewing in terms of Daily Runs and Warning Days

Number Boolean Warning Day Events (All CAT)

WD1

WD2

WD3

WDX
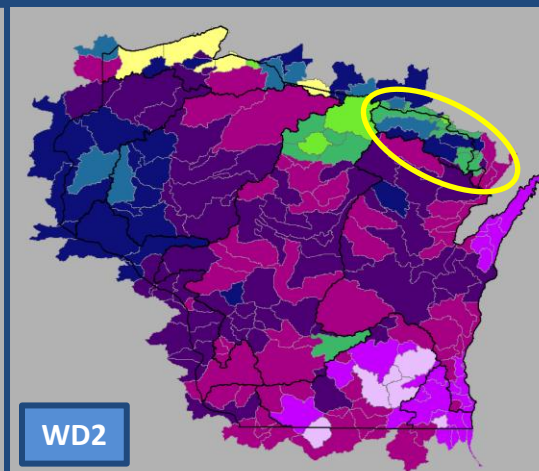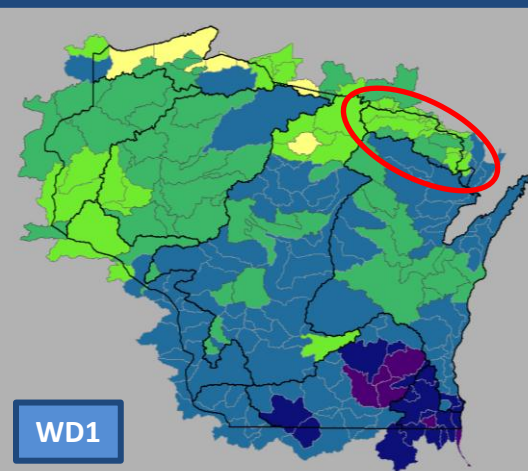
➢ **Viewing in the Warning Day mode shows that the end user will see irregular forecasts for this particular region as some basins will be flagged with events more often than neighbors**

➢ **Particular interest is in the streak of lower events along the state border**

Number Boolean Events (All CAT)

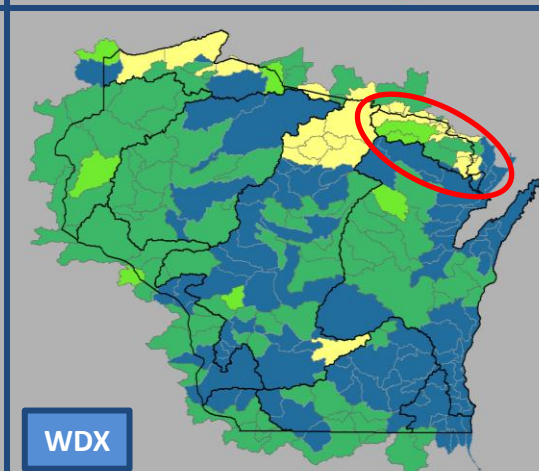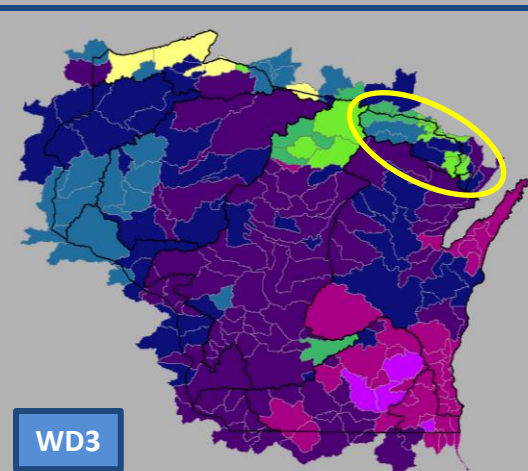|	
	0 - 20
	21 - 40
	41 - 60
	61 - 80
	81 - 100
	101 - 120
	121 - 140
	141 - 160
	161 - 180
	181 - 200
	201 - 220

Investigating Northeastern Wisconsin

Surface Lithology

NLCD 2006 Land Cover

Land Surface Forms

Legend (Surface Lithology):
- Carbonate Residual Material
- Non-Carbonate Residual Material
- Alkaline Intrusive Volcanic Rock
- Silicic Residual Material
- Extrusive Volcanic Rock
- Colluvial Sediment
- Glacial Till, Clayey
- Glacial Till, Loamy
- Glacial Till, Coarse-Textured
- Glacial Outwash and Glacial Lake Sediment, Coarse-Textured
- Glacial Lake Sediment, Fine-Textured
- Hydric, Peat and Muck
- Eolian Sediment, Coarse-Textured (Sand Dunes)
- Eolian Sediment, Fine-Textured (Glacial Loess)
- Saline Lake Sediment
- Alluvium and Fine-Textured Coastal Zone Sediment
- Coastal Zone Sediment, Coarse-Textured
- Water

Legend (NLCD 2006 Land Cover):
- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Consolidated Shore
- Deciduous Forest
- Evergeen Forest
- Mixed Forest
- Shrub/Scrub
- Grasslands/Herbaccous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaccous Wetlands

Legend (Land Surface Forms):
- Flat Plains
- Smooth Plains
- Irregular Plains
- Escarpments
- Low Hills
- Hills
- Breaks/Foothills
- Low Mountains
- High Mountains/Deep Canyons
- Drainage Channels

- **In general this area is reasonably similar in surface features. Exceptions arise as moving to less forest cover towards the southern edge and less wetlands moving eastward**
- **Doesn't seem to be strong evidence for physical reasons for a large disparity in interflow runoff simulations among the basins**
- **SAC and Snow17 parameters do indicate a few basins with some values on the fringe of the regional average**
- **However, this area does simulate fairly well for streamflow forecasting (main NCRFC focus)**
- **This disparity in model parameters probably due to lack of observed data when calibrating thus regionalized values perhaps spread in from the south and east to be applied to some basins**

- **ACTION ::**
  - *As this area involves several basins to investigate it will probably be awhile before any in-depth parameter analysis will be done*
  - *Its acknowledged that this area probably doesn't support much manure application operations*
  - *However, since it is currently on the map, the end user will observe discontinuities and therefore could damage the perceived usefulness of the RRAF across the rest of the state*
  - *Its proposed that the basins in this region which do not generate interflow runoff be evaluated to determine if they should be responding similar to neighboring basins*
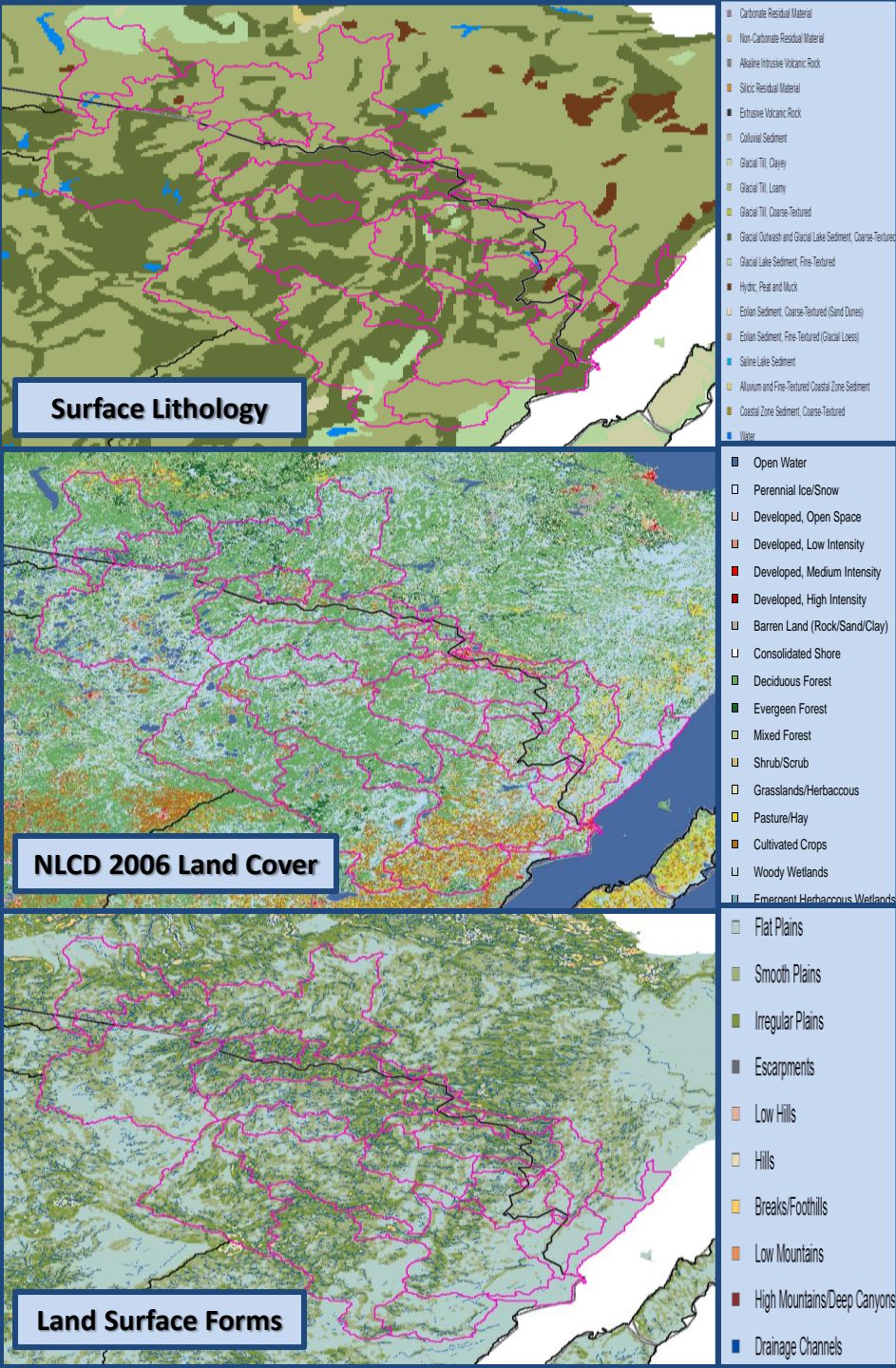
Overview

1. **Introduce Analysis Details & Goal**

2. **Review Simulated Runoff Event Definition**

3. **Review Runoff Event Categories & Thresholds**

4. **Introduce Concept of Runoff Type**

5. **Introduce concept of a "Warning Day"**

6. **Review Assorted Histograms and Spatial Maps**

7. **Identify Inconsistent Basin Behavior & Opportunities for Improvement**

8. **Next Steps**

National Weather Service

Protecting Lives and Property
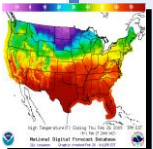
Next Steps

- **Discuss findings internally at NCRFC**
  - *Suggest timeframe for adjusting problem basins found in analysis*
  - *Short Term Changes*
    - **PDSW3, SPAW3, WI12C, WI13C, WI14C, WI15C**
  - *Adjusting Basins in next 2 – 4 Months*
    - **SOSW3, MRNM4**
  - *Adjusting Basins in next 6 Months*
    - **Northeastern Wisconsin Basins**

- **Timeliness of these proposed changes will depend on NCRFC operations and other project development priorities.**

- **Focus shifts to working on paper describing this project**

- **Feedback and thoughts on the 2011 analysis or current product the NCRFC is supporting is encouraged**
  - *Dustin Goering :: dustin.goering@noaa.gov*

- **http://www.manureadvisorysystem.wi.gov/app/events/runoff_forecast**